Instruments

THE MAGAZINE of MEASUREMENT and CONTROL

Vol. 21 | NOVEMBER 1948 | No. 11

Including the *JOURNAL* of the Instrument Society of America

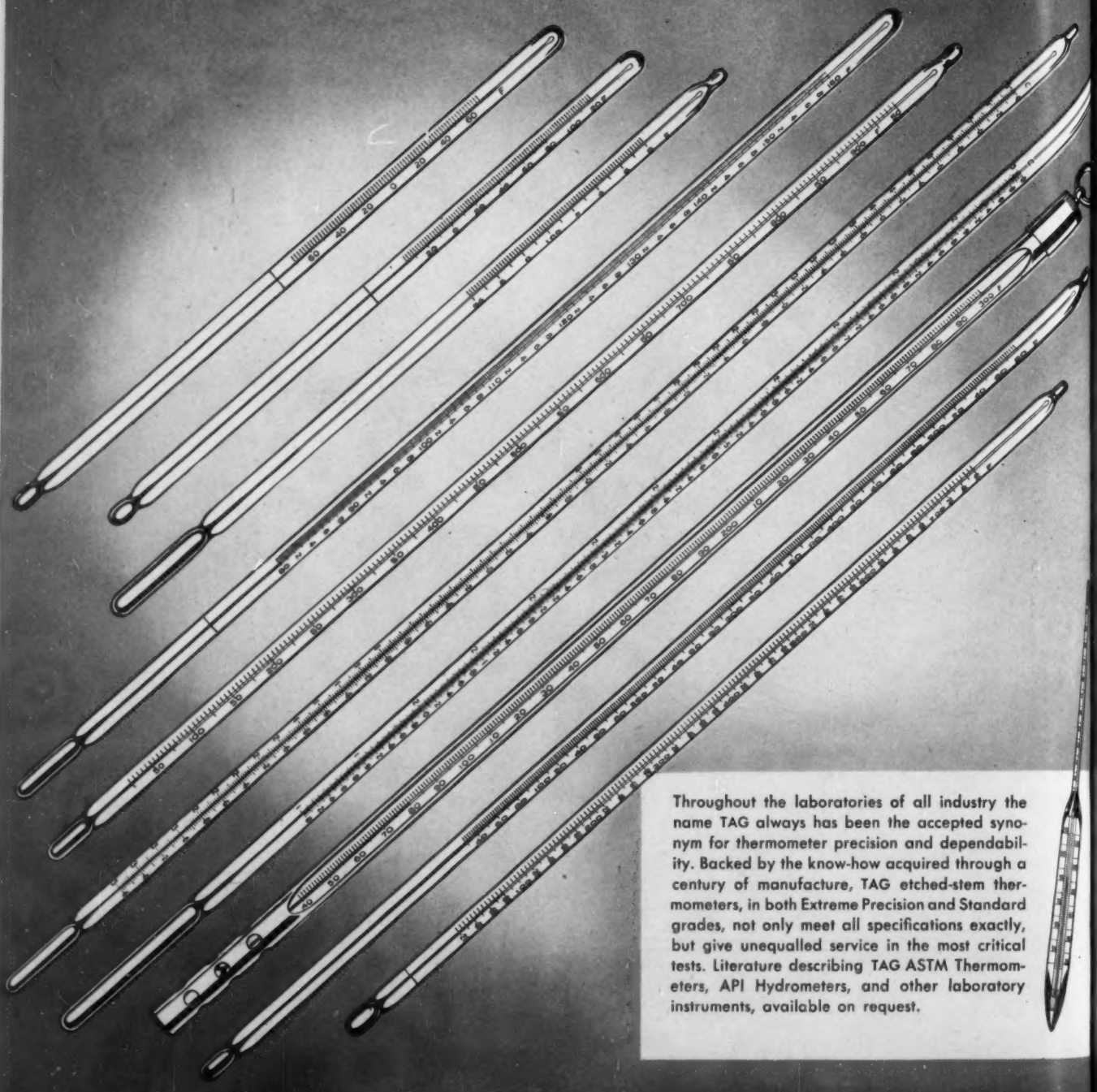
Instrumentation of Cold-reduction Mill at Columbia Steel, Pittsburg, Calif.

(Article on Page 1011)

TAG *Precision*

ETCHED-STEM

THERMOMETERS



Throughout the laboratories of all industry the name TAG always has been the accepted synonym for thermometer precision and dependability. Backed by the know-how acquired through a century of manufacture, TAG etched-stem thermometers, in both Extreme Precision and Standard grades, not only meet all specifications exactly, but give unequalled service in the most critical tests. Literature describing TAG ASTM Thermometers, API Hydrometers, and other laboratory instruments, available on request.

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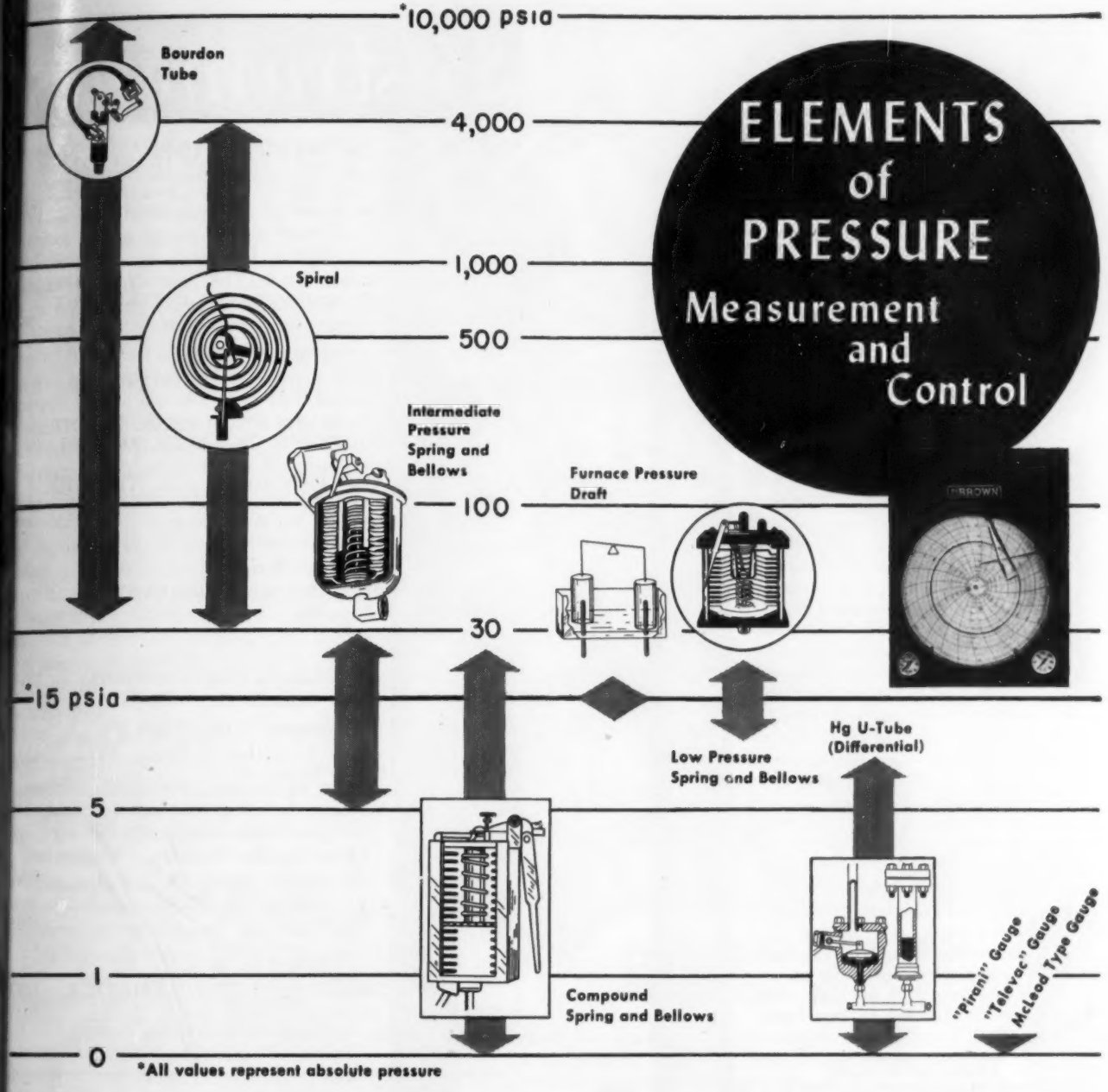

FROM tons to microns—never underestimate the importance of precise pressure control of your processes. The effect of slight pressure inaccuracies has proven to be more far-reaching than is commonly suspected.

Proper handling of pressure problems necessitates a full line of pressure elements—not just making one element do for a variety of applications. The complete line of pressure equipment, and broad knowledge of its application, available through The Brown Instrument Company is unsurpassed.

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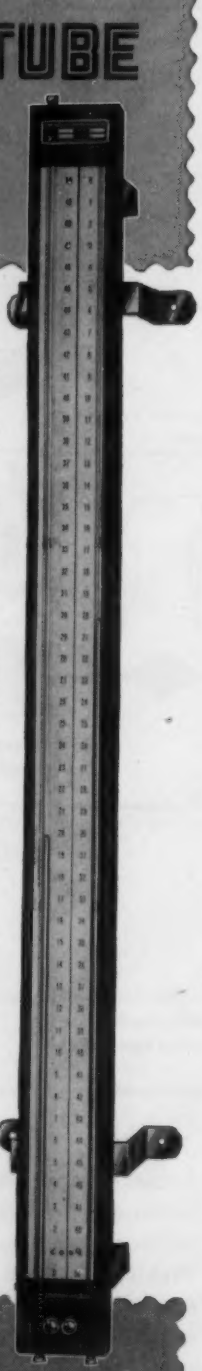
BROWN *Advanced Instrumentation* **FOR BETTER PROCESSING**
Product of MINNEAPOLIS **Honeywell**

Announcing the

DUAL-TUBE

Something Brand New in MANOMETERS by MERIAM



● Now, instead of standing on a step ladder—as when reading long range, single column manometers—the operator can read high range pressures, vacuums, and differentials from the floor level.

This new manometer development—the DUAL-TUBE, Meriam Model M-100 — consists of two separate manometer tubes in the same case—each tube with individual well. The left tube has a scale increasing upward; the right tube a scale increasing downward. Both tubes are connected in parallel to the same pressure source.

The instrument is ideal as a calibrating standard manometer for checking flow meters, pressure gauges, and other secondary units operating on pressure or vacuum principle. It is direct reading. Since both tubes indicate the same reading, the operator can choose the one most convenient.

It helps avoid accidents, saves time and effort in reading. Of simple, rugged construction, it is built in accordance with Meriam standards of accuracy and sensitivity for long, reliable service. Ask for Catalog Sheet M-100WM.

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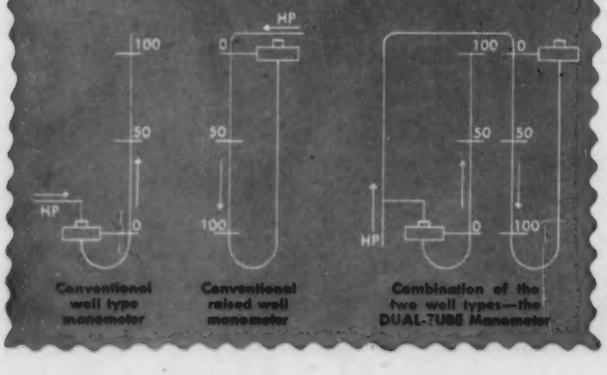
IN CANADA: Peacock Bros., Ltd., Montreal

MERIAM DUAL-TUBE MANOMETER.
Available in ranges of 50" to 150".
Patent applied for.



Instruments

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THE STORY BEHIND ACCURACY TO SPARE

The many products to which cold-drawn seamless tubing is now being applied require accuracy from any number of standpoints. For pointer tubing, the instrument manufacturer wants precise strength-to-weight ratio for balance and to withstand striking a stop pin. For Bourdon gauges, shape, size, and metallurgical properties must be accurate for reliable indication of the slightest pressure variations. The mechanical pencil manufacturer requires dimensional accuracy for perfect fit of component parts. The electronic user seeks concentricity for coaxial conductors. How ever the tubing is used, all manufacturers usually stress one characteristic that must be carefully observed in tubing production.

Accuracy is no accident. Its fulfillment requires a production system in which supervisors fully understand the use to which each length of tubing will be put. Production men, in turn, must be instructed properly and must possess specialized skills to carry out such high standards.

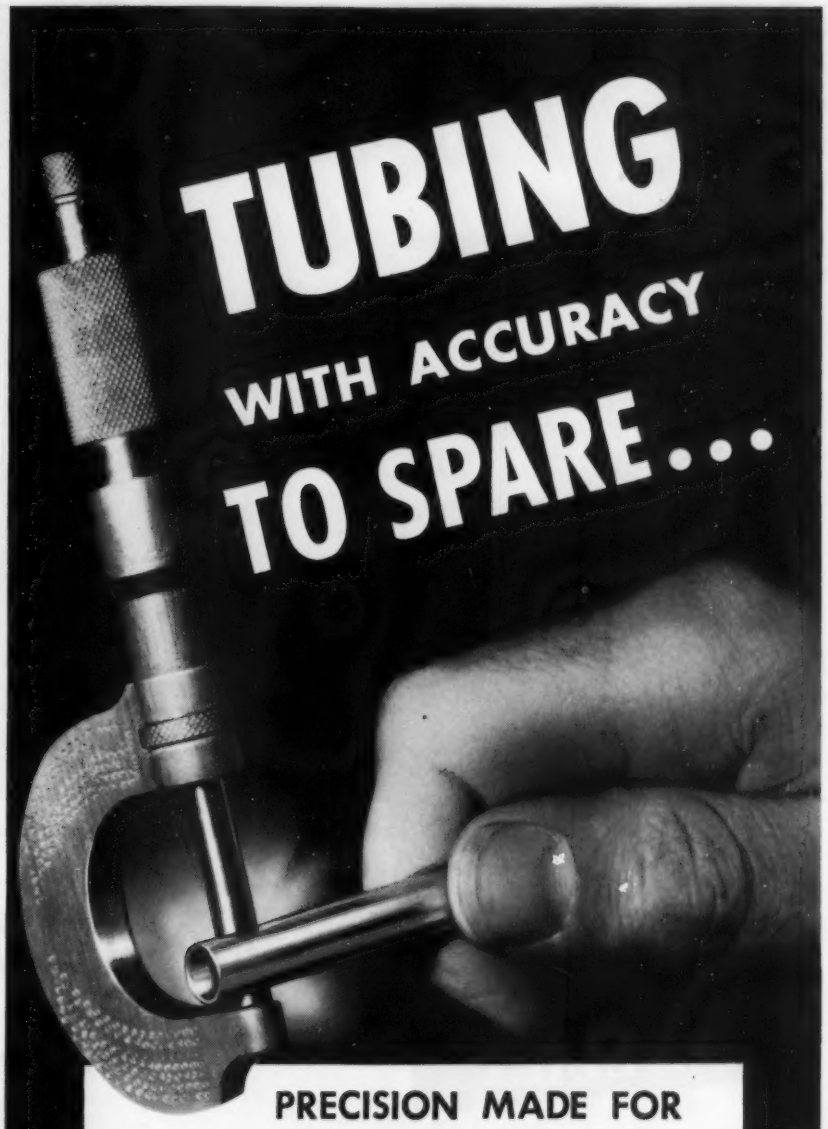
Tooling, for example, can be only the best. No makeshift practices can be tolerated. Moreover, these tools must be checked frequently to make certain they are in perfect condition with duplicates ready if needed.

The metallurgist's position in maintaining accuracy is highly important. He must properly specify heat and load cycles for each anneal and take responsibility for conformance of the finished material with the customer's order.

The chemist is also important in Precision Tubing manufacture. His contribution of knowledge of lubrication and cleaning methods are vital to tool wear. Top accuracy is impossible if tools change from the beginning to the end of a production run. If mineral base lubricants are used, sulphur content is vital. With water soluble lubricants, staining is a major problem. In either case, proper cleansing methods must be devised.

Finally, the inspector must be skilled in the use of instruments. He must have at his disposal all specifications and be able to apply his instruments so that only tubing which meets specifications is released.

Thus, it can be seen that Precision's production requires a combination of many skills. Each individual directly involved must possess years of know-how and the firm desire to do a good job. Accuracy to Spare must result from team work to spare in any industry.



PRECISION MADE FOR PRECISION PRODUCTS

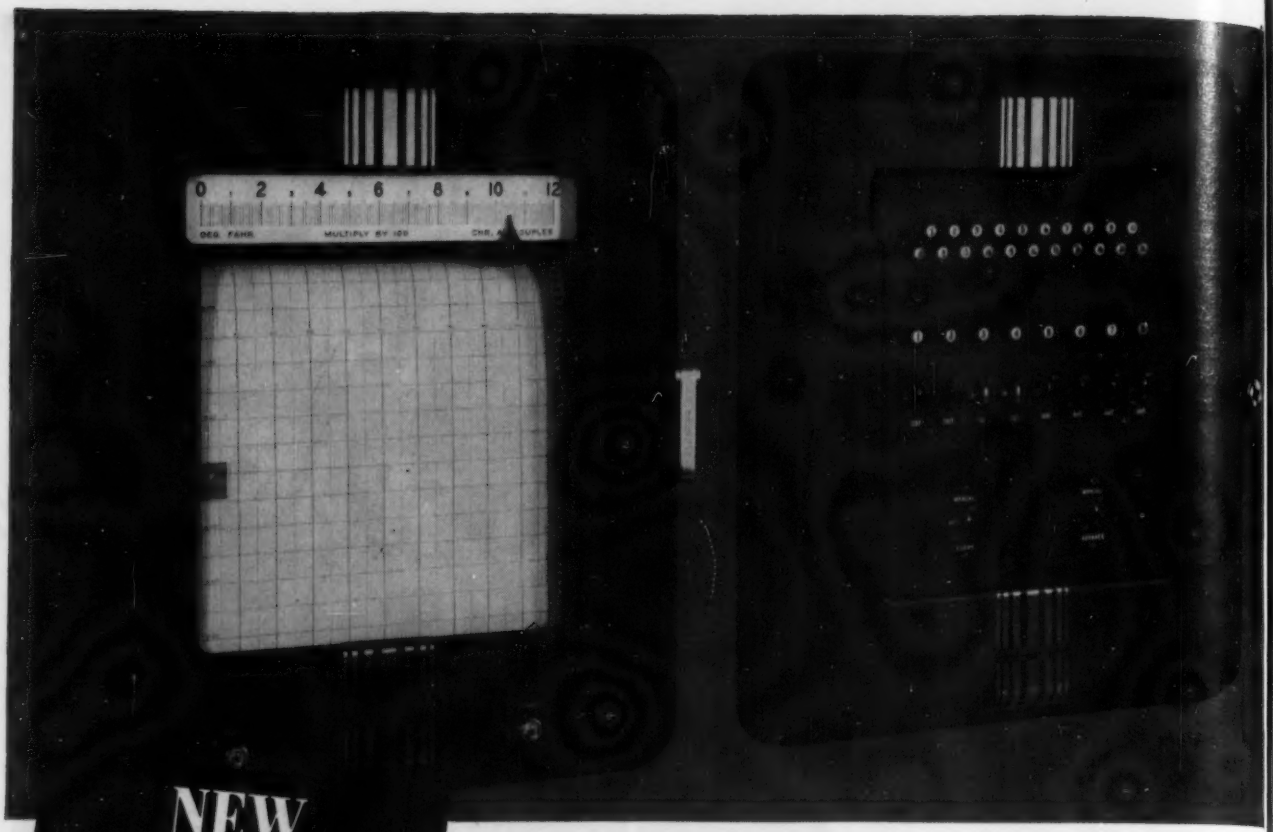
When you specify seamless tubing—whether it's for instrument pointers, Bourdon gauges, metal-shielded wire, mechanical pencils, or any one of a number of products—here, at Precision, accuracy is our watch-word. Inside diameter, outside diameter, wall thickness—all dimensions are held to close tolerances, often exceeding those specified. In this way the over-all accuracy you want in your finished products is consistently carried out in our part of their manufacture.

Sizes of Precision Tubing cover a range of outside diameters from 0.500″ to 0.010″, with wall thicknesses down to 0.0015″. Available in aluminum alloys, brass, copper, nickel, monel, or other non-ferrous alloys—each length of Precision Tubing can be preformed to the shape you specify . . . ready on good delivery.

When Precision Counts—Count on Precision

PRECISION TUBE CO.

Factory: 3824-26-28 TERRACE ST., PHILADELPHIA, PA.



NEW PROTECTOR FOR BOILERS

Checks 160 Tube Temperatures In Only 10.6 Minutes!

Remarkably fast, this new Speedomax equipment offers a definite advance in protection for large boilers. With it, the shift operator can "tour" the temperatures of 160 tubes in a little less than eleven minutes. He can stand and watch the readings as they are automatically indicated; or Speedomax will record them for later examination and for the shift log.

In either case, readings are supplied in such rapid rotation that it is generally possible to determine the exact point at which any high or low temperature first develops, even though the condition may later spread to other points. This speed thus helps both to detect and to isolate trouble.

The installation procedure is familiar to most power engineers. The power company's staff simply makes up thermocouples and attaches them to the tubes which they decide will give the most useful temperature readings. Conventional-type couples, at points outside the gas passages, are of course usually included in the installation. Couples are connected to the Speedomax equipment in 8 banks of 20 each, and appropriate alarms are included.

Records When Desired

The Speedomax automatically measures these temperatures at a rate of one every 4 seconds. Signal lights wink on for each couple, and as long as temperature remains correct the instrument merely indicates . . . does not record. It can be made to record at any time, however, by merely throwing a switch. Or if any temperature reaches its predetermined limit, an alarm sounds and the Speedomax automatically records until switched off. Also, any bank or banks of couples can be switched out at any time, thus concentrating on areas of special interest.

For further information about these equipments, please write Leeds & Northrup Company, 4955 Stenton Ave., Philadelphia 44, Pa.

Substantially The Same Equipment Can Be Used For Turbine and Generator-Bearing Temperatures

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Jrl. Ad N-33A-463(3)

Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

"Forgotten" Instrument Men

MOST subscribers (other than those whose secretaries attend to such matters) are familiar with the renewal form sent by our Circulation Department. This form has blanks for "Company" and "Products Manufactured" to be filled in.

One loyal subscriber has renewed year after year, but he has not filled in the blanks because he could not fill them in. He is not the only one (a simple questionnaire cannot be universally applicable) but this year he has kindly taken the trouble to explain why. His letter is of such general interest that we print it in full:

Instruments Publishing Co.

Sirs: Up to now I have been ignoring your questionnaires because I work for no one employer and no products are manufactured.

I am writing this because I cannot answer without explanation and complaint. I am complaining about the fact that instrument manufacturers and dealers seem to ignore the man in the field who is called upon to install their equipment and turn it over to the owner in a satisfactory operating condition.

I am a journeyman electrical wireman. I sell no equipment directly. I install equipment furnished by others, chiefly salesmen whose prime interest is to sell the product. The equipment is usually bought through a purchasing department on orders from some engineer in some office, perhaps in the same office, perhaps miles removed, who, on arrival of the article, looks at it, remarks how nice! and then retains the instruction sheets for his own files, leaving the instrument to be put into operation by us, the men who do the work and sweat and swear until it works properly.

I think too little consideration has been given the man in the field. In the smaller plants I have found myself in the position many times of advising and recommending to the owner or manager a particular type of instrument for the problem at hand so that indirectly we are the actual salesmen involved in that transaction.

Now to illustrate. During the last year only I installed (was foreman in charge of installing)

(1) A 3500-hp. high-voltage motor, wattmeter-controlled, having a contact-making wattmeter, two recording wattmeters, telephone type d-c. relays, power factor meter, and the customary switchboard panel instruments.

(2) A Sperry Gyrocompass and auxiliaries.

(3) Several Brown instruments on drying equipment.

(4) Control equipment on biological incubators.

(5) Control equipment on warming ovens in a large candy factory.

(6) Photocell controls on wrapping machines.

(7) Generating unit including all control equipment (voltage controls) and all instruments including frequency and synchronization.

(8) All wiring for 37 different instruments in a pilot plant for a large oil company's laboratories including several still in the experimental stage.

In all the foregoing the only company having an instrument department was the oil company. All the others were supplied through the engineers employed by the electrical contractor whose main concern was sales.

Now to the reason I am taking the magazine: Primarily because it is one way of finding out what is on the market and in a limited way to find out how it works so that I may be able to install it intelligently when I meet it in the field.

In the foregoing I spoke mainly from my own experience but I firmly believe that it applies in varying degree to all electricians working in the industrial field whether they are in charge or merely in a crew. I think that it is nearly as important to have an instrument installed satisfactorily as it is to sell it, for an unsatisfactory job means a lost customer.

What I have been trying to point out is that we in the electrical business, the ultimate installers, are indirectly the men responsible for a large part of the repeat sales and that our approval or disapproval of a product counts most with the smaller owner, who, in the aggregate, is the largest purchaser.

Now with the above explanation I feel that you will understand my answer to your questionnaire.

Oakland, Calif R. CHISHOLM

When this letter was referred to your editor, it brought to memory other examples of Instrument Men placed in the awkward position of having to install instruments without printed or mimeographed instruction sheets. The plight of these men has been publicized several times* and various helpful measures were taken locally and temporarily, but no one has ever proposed a COMPLETE and PERMANENT solution that would not be prohibitively expensive. No nationally-recognized organization has even taken the first step, namely, to discover and define the elements of the problem. Therefore we repeat what we preached before:

There is a crying need for general agreement on definitions of the four terms: "Installation," "Care," "Maintenance" and "Servicing"; also for better understanding as to the dividing line (or lines) between the maker's and the user's responsibility.

*See in particular the editorial entitled "Installation," "Care," "Maintenance" and "Service," *Instruments*, March 1941, pages 51 and 72, discussing actual cases which had been reported at the February 1941 meeting of the ASM&C.

To which we should have added (and now add)

"... to define the responsibilities of Instrument Men who are neither makers nor users but who install, adjust and place into operation the maker's instruments in the user's plant or lab; and to keep such Instrument Men supplied in advance with up-to-date and specific instruction sheets."

No Can Do

ANOTHER subscriber, after thanking *Instruments* for James Spencer's serials on servicing indicating instruments, requests a similar serial on the "troubles of the ..... Recorder-Controller." PERHAPS he was jesting. CERTAINLY, all manufacturers of self-balancing potentiometers and bridges supply complete instructions. A serial on ALL servicing details of ALL these instruments would run to thousands of pages and would be 99% what is available from the makers.

Scientific ⟶ Industrial
Industrial ⟶ Scientific

IF we again labored the point that today's scientific instruments are tomorrow's industrial instruments, you'd be bored. Another point—made several times on this page—deserves to be heeded. It is that the time has passed for any new measurement method to be embodied in an assembly made up entirely of newly-designed components. Instrument designers and builders in research laboratories have a perfect right to take pride in their work . . . BUT — when a physicist brings the sketch of a new apparatus, there's no logic in designing and fabricating new bolts and nuts or new binding-posts, is there? Well, there's no logic in designing and building new resistors or tubes or amplifiers or millivoltmeters or recorders when such components are on the market. Anyone who has recently visited laboratories where new measurements are being made has noticed that some of the wonderful new "machines" are equipped with control boards resembling control boards in industrial plants and—like plant jobs—made up of regular catalog items: not a special in a carload.

This photograph of the Exposition does not adequately bring out its size. Actual length of the Exhibit Floor in the Auditorium (as marked on architects' plan) is 225 feet 7 inches; extreme width is 103 feet 4 inches.

Southern California Meter Association's Twenty-first Anniversary Instrument Exposition

HAILED by disinterested reporters as "the largest and most complete exhibit to be held in the West in many years," a Measurement and Control Exposition was held October 22 and 23 in the Municipal Auditorium at Long Beach (about fifteen miles south of Los Angeles) California. Fifty manufacturers, institutions, engineering firms, etc., displayed their products and services.

Sponsor was the Southern California Meter Association, which last summer completed twenty-one years of distinguished service. A quarter-century ago the oil boom in Southern California had brought with it tremendous flows of natural gas. The problem of standardizing the measurement of this gas led, indirectly, to the formation of the SCMA. Many companies were engaged in gas production, use and distribution. They all used orifice type primary elements and differential-pressure type metering instruments, but they used various types of installations and widely-different methods of interpreting and computing their meter charts. So inaccurate were the measurements and the computing methods that a discrepancy of five percent between supplier and receiver was considered "within reason."

Early in 1927, the need of an organization had become acute. Led by T. K. M. Smith of the Industrial Fuel Supply Co., a group of men working with meters and instruments for the various utility and oil companies handling natural gas in the Los Angeles Basin area decided to form an association for exchanging information and ideas and for establishing and adopting standard metering procedures.

Twelve of these men, representing twelve different companies, met on July 14, 1927, in the offices of the Industrial Fuel Supply Co., in Anaheim for a preliminary organization meeting. Two

Exhibitors and Local Addresses

American Meter Co., 2118 Atlantic St., L.A. 21
American Recording Chart Co., 3113 E. 11th St., L.A. 23
American Society of Mechanical Engineers, 2307 E. 8th St., L.A. 21
Annin Co., 3234 Mines Ave., L.A. 23
Barton Instrument Co., 3500 Union Pacific Ave., L.A. 23
Berkley Engineering & Equipment Co., 2417 Riverside Dr., L.A. 26
Bristol Co., 736 E. Washington Blvd., L.A. 21
Ralph N. Brodie Co., 2101 So. San Pedro, L.A. 11
Builders-Pacific Co., Inc., 2085 Belgrave Ave., Huntington Park
California Nat. Gasoline Asso., 510 W. 6th St., L.A. 14
J. A. Campbell Co., 645 E. Wardlow Rd., Long Beach 7
California Oil World, 706 So. Valencia St., L.A. 14
The ChartOmatic Co., 2068 E. 37th St., L.A. 11
Daniel Orifice Fitting Co., 3352 Union Pacific Ave., L.A. 23
Deutsch Company, 7000 Avalon Blvd., L.A. 3
N. F. Dundas Co., 1417 No. Main St., L.A. 12
Fisher Governor Co., 2334 E. 8th St., L.A. 12
The Fluor Corp., 2500 S. Atlantic Blvd., L.A. 22
The Foxboro Co., 2307 E. 8th St., L.A. 21
Adolf Frese Corp., 116 W. 17th St., L.A. 15
Gas Magazine, 1709 W. 8th St., Suite 320, L.A. 14
Gordon Z. Greene, 2335 E. 8th St., L.A. 21
Hammel-Dahl Co., 243 Richmond St., Providence 3, (R.I.)
Howard Supply Co., 5125 Sante Fe Ave., L.A. 11
W. D. Howze & Co., 323 W. 5th St., L.A. 13
Instruments Publishing Co., 2721 N. Marengo Ave., Altadena
Jensen Instrument Co., 335 S. Central Ave., L.A. 13
W. R. Ladewig Co., 238 S. San Pedro St., L.A. 12
Long Beach City College, 8th & American Ave., Long Beach
Manning, Maxwell & Moore, Inc., 1325 Sante Fe Ave., L.A. 21
Mason-Neilan Regulator Co., 1457 S. Concord St., L.A. 23
Material Service Co., 5159 E. Olympic Blvd., L.A. 22
Meletron Corp., 950 N. Highland Ave., L.A. 38
Meriam Instrument Co., 6311 N. Figueroa St., L.A. 42
Mills Iron Works, 929 N. Main St., L.A. 12
Natural Gas Equipment Co., 714 W. Olympic Blvd., L.A. 15
Oil Magazine, 124 W. 4th St., L.A. 13
Pacific Laboratory Apparatus, 3555 Whittier, L.A. 23
C. W. Parsons, 4135 Union Pacific Ave., L.A. 23
Parkhill-Wade Co., 5017 Anaheim-Telegraph Rd., L.A.
Permutit Co., 124 W. 6th St., L.A. 14
Petroleum World, 412 W. 6th St., L.A. 14
Pipe-Fabricating & Supply, 2216 N. Alameda St., Compton 2
Pittsburgh Equitable Meter Co., 3136 E. 11th St., L.A. 23
Precision Maintenance Co., 2425 Gundry, Long Beach 6
Reliance Regulator Corp., 1000 Meridan Ave., Alhambra
Robinson Orifice Fittings, 1435 Santa Fe, L.A. 21
Smith Meter Co., 5743 Smithway St., L.A. 22
Sprague Meter Co., 2840 E. 11th St., L.A. 23
Taylor Instrument Companies, 815 W. 9th St., L.A. 15

weeks later, a general meeting in Anaheim was attended by 57 men from 15 different companies. At this meeting was founded the association which now has a membership of over 400.

It is interesting to note that 42 of the original first year's membership of 132 are still members of the association; and that all but one of the past presidents are still members.

T. K. M. Smith was selected first president. B. M. Laulhere of the Midway Gas Co., (now Southern California Gas Co.) was named vice president and later became its second president. R. N. Brown, Union Oil Co., served as secretary and E. C. Spencer, California Gasoline Co., as treasurer. Drafting of the constitution was the work of the by-laws committee, of which W. M. Bradford, West Coast Refining Co., served as chairman. H. E. Thompson, Los Angeles Gas and Electric Corp., also contributed a great deal to the committee's efforts.

Dual Purpose

"The activities of this Association shall at all times be guided by a dual purpose: (a) To ascertain the facts wherever differences of practice, procedure or opinion regarding fluid meters, instruments or controllers exists, to duly substantiate same by practical and scientific methods, and report same in formal papers designed to be filed among the archives of the Association, to the end that the resulting material or information may be equally available to all members. (b) To compile a booklet of systematically arranged information pertaining broadly to fluid meters, instruments or controllers, and publish the same over the name of the Association."

Benefit of membership has always been open to anyone who would signify a willingness to support the association. No company or corporation has a voice in the government of the SCMA.

Dinner meetings are held each month; manufacturers or their sales representatives, who are sustaining members of the association, are given a chance to display new equipment, usually with demonstrations.

The June meeting is the "Low-Jinks," when election of officers and a show take up the evening. February is the month of the annual Hi-Jinks."

Technical papers presented before the association are mimeographed and mailed to all members. Members also receive new data sheets or revisions developed for the association's handbook.

The SCMA has four classes of membership: active, associate, sustaining and affiliated. Active membership is extended to those engaged in the actual measurement and control of fluids; associate membership is open to those connected with the design, manufacture or sale of fluid meters, regulators or any equipment pertaining to the measurement or control of fluids. Sustaining membership is extended to any firm, company or corporation employing individuals as set forth in the two classes listed above. Affiliated membership is for anyone not heretofore classified, but who is interested in the measurement and control of fluids. Life Membership awards have been conferred on four members in recognition of their notable work: B. G. Williams, fifth president and one of the founders, now retired from Southern California Gas Co.; B. M. Laulhere, second president and also one of the founders, now on medical leave from Southern California Gas Co.; Gordon S. Duncan, General Petroleum Corp., former secretary; and J. A. Gendron, charter member, now retired from Southern California Gas Co., and affiliated with Refinery Maintenance Co.

Through the joint efforts of the SCMA., the California Natural Gasoline Association and the Pacific Coast Gas Association, several bulletins on procedure for the measurement of natural gas by the orifice meters have been developed and are used as standard practice for all the companies on the West Coast. Also, recognizing the widespread need for courses of instruction in the various branches of measurement engineering, the SCMA organized an educational department, made up of outstanding measurement engineers of Southern California.

Today the SCMA is recognized as a permanent agency for interchange of experience and knowledge among men whose interests lie in fluid measurement; and the results will continue to be passed along to the companies represented in the membership through improved measurement practice. General benefits accrue also from greater uniformity in metering and measurement accounting.

In 1927, a 5% discrepancy was considered "within reason"; today some flows of butane are measured by orifice meters and the average difference between the buyer's and the seller's meters, over a 30-day period, is FOUR-TENTHS OF ONE PERCENT.

ACKNOWLEDGMENT.—The writer takes pleasure in acknowledging his indebtedness to *Petroleum World* (Los Angeles 14, Calif.). Much of the material on these two pages has been copied word for word from articles and "shorts" prepared by the editorial staff of that magazine and from an article by J. C. Groenewegen prepared also for that magazine.—M. F. BEHAR.

Some SCMA Notables

J. C. GROENEWEGEN, President. Joined SCMA in its first year. Served as Chairman of the Program, Instrumentation, and By-Laws Committees; also as Vice-President and in other capacities. *(Instrument Foreman of Shell Oil Co., with which he has been for the past twenty-five years.)*

E. P. VALBY, Vice-President, has held various offices and served two years as Standards Chairman. *(Gas Engineer, Richfield Oil Corp.)*

G. H. FORSTER, Jr., Secretary-Treasurer for the fifth year and Past President; also Secretary of Exposition Committee. *(Gas Dispatcher, The Texas Co.)*

J. E. GESNER, General Chairman of Exposition Committee. *(Sales Eng. Reliance Regulator Corp.)*

C. G. CORTELYOU, Assistant Chairman of Exposition Committee, is a Past President and served also as Auditor, Program Chairman and Vice-President. Known as "the man behind the Exposition." *(Job Engineer, General Petroleum Corp.)*

J. E. ADAMS, Program Chairman for second year, also Housing Chairman, also Treasurer of Exposition Committee. *(Test Engineer, Signal Oil & Gas Co.)*

H. M. KEMMERER, Auditor. *(Division Field Engineer, Southern Counties Gas Co.)*

B. E. POWELL, Standards Chairman. *(Instrument Engineer, Standard Oil Co. of California.)*

R. F. FIELDS, Membership Chairman. *(District Sub-Foreman, Southern California Gas Co.)*

F. G. CARTER, Entertainment Chairman. *(Manager, California Specialties Co.)*

R. T. FURLONG, San Joaquin Valley Chairman for the fifth year. *(District Gas Engineer, The Texas Co.)*

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SCMA President J. C. Groenewegen *(left)* visits The Instrument Publishing Company's booth at the Exposition. *(Center)* IPC President Rimbach; *(right)* IPC West Coast Manager Pugh.

A New Type *of* Electrical Instrument*

By KEATS A. PULLEN, Pratt Institute, Brooklyn, N. Y.

RAPID development of the electrical and electronic fields during the past few years has produced many new measuring problems. In addition, mechanical requirements have become more stringent because of vibration conditions in aircraft, railway, automotive and portable welding, radio and other equipments of all types.

Mechanically, a movement injury is either damage of the pivot and/or pivot cup; or destruction of proper alignment of the pointer and deflecting element and/or the balancing weights. The pivot may have its point deformed or the pivot cup jewel may be chipped or cracked if high vibration or shock stresses occur along the movement axis. If the vibration or shock is applied normal to the axis, the poising of the movement may be impaired by a shift in position of any of the masses of the system. A sufficiently strong shock may render the movement inoperative.

Electrically, better efficiency in a light-weight movement is needed. Improved control of scale distribution is likewise needed — to help eliminate errors resulting from shifts of pointer position and to permit wider use of sensitivity-control technique.

These problems call for a new approach.

The New Approach

One possible solution to these problems is the use of a double-moving-coil system (see Fig. 1). In this solution the coils are mounted on opposite end of support frames which carry the pivots at the center. The pointer itself is an extension of the upper frame. The two coils are connected in series to produce magnetic fields of the indicated polarities. The ring on which the coils move is either cast or laminated. The cast form would be made of Alnico V or similar material; the laminated form, of low-loss transformer steel. In the latter case additional coils (not shown) are required to supply the magnetic field for operation. The polarities of magnets and moving coils are indicated in Fig. 1, as is the direction of the moving coils.

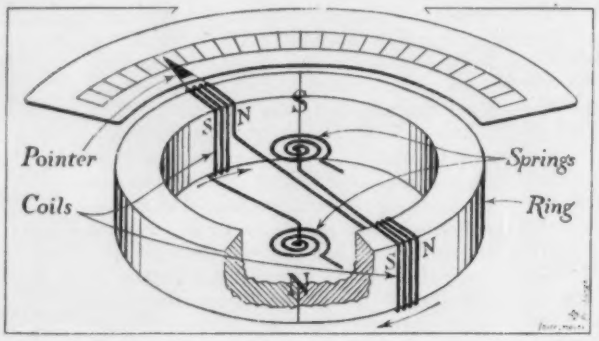


Fig. 1

The operation of the movement when using a pair of magnets on the stationary structure depends upon the flux leakage across the ring. This leakage takes place from the outer surface and edges of the ring as well as from the inner surface. Since the relative current and flux directions on all four surfaces give motional force in the same direction, *all the copper in the coil is effective in producing instrument torque. Moreover, the two coils can be connected in such a manner as to yield additive torque.*

Using the magnet as stationary structure, the movement measures the average value of current through the coils. In order for the combination of magnets and coils to operate effectively, the magnets must be assembled with their fields opposing. The needed leakage flux then is found in the regions near the ends of the magnets. Since there is a 50-degree range along the magnet on either side of the break having magnetic leakage of the same polarity, the moving element swings over this range. The resulting movement has electrical characteristics similar to those of the d'Arsonval* movement. Under mechanical shock, however, the coils, which are the heaviest elements, will be deflected until they contact the magnet structure, which will cushion them and prevent stresses high enough to cause damage.

In the other form, the laminated transformer steel stationary section is used with exciting coils for the production of the magnetic field. In this form, the movement measures the scalar product of two currents. The exciter coils are connected to yield two opposing electromagnets. As a result, the leakage flux again is high. With the stationary and moving coils in series, the movement reads effective current or effective voltage. With the stationary coils connected to a current circuit and the moving coils to a potential circuit, power, reactive power, etc., can be read. Hence, this movement has properties similar to those of the dynamometer type. Its mechanical shock characteristics are similar to the magnet-form of this movement.

In this type of movement, the pointer length can be very short. Also, since the deflection coils are displaced from the axis, the torque will be high. This permits use of strong springs and yields a large torque-to-weight ratio.

*First manuscript, received in May 1947, was author's Doctorate Thesis; was not suitable for *Instruments*. This is a revised version.—Editor.

*Editor's Note.—Ordinarily we substitute "permanent-magnet moving-coil movement" for "d'Arsonval movement" in all manuscripts that pass through our hands, because the p-m.m-c. movement of today is more Weston's than d'Arsonval's; but Dr. Pullen here describes a new type of p-m.m-c. movement which is neither a d'Arsonval nor a Weston.—MFB.

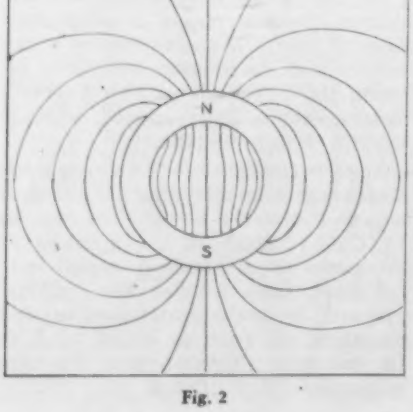


Fig. 2

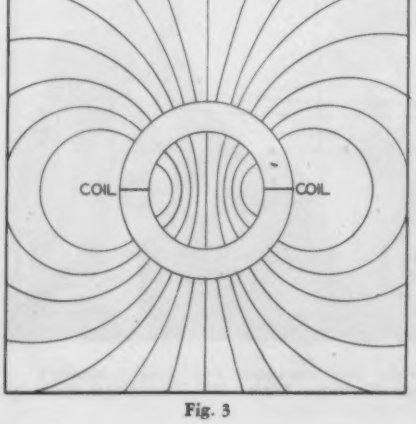


Fig. 3

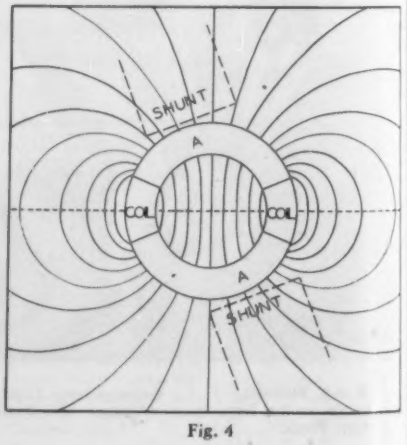


Fig. 4

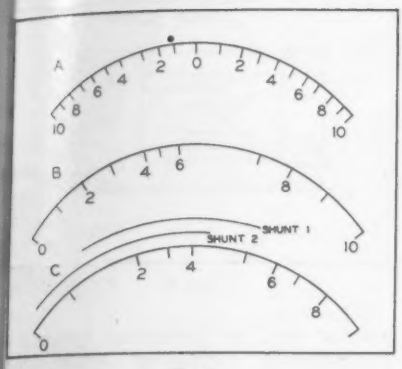


Fig. 5

Theory of Operation

The new movement depends for its operation upon flux leaking off the ring surfaces. If $\delta\beta$ is the average density of the leakage flux leaving the ring under a coil (see Fig. 12), the deflecting torque for the two coils is

$$T = \tau\theta = 2nil\delta\beta r \qquad (1)$$

The derivation may be found in Appendix 1.* It can be seen that, for two movements of the same total weight, the torque T is greater if the radius of action r is large.

Since operation of the movement depends upon leakage flux from the core structure, the magnetic field distributions are of interest. Analysis of the two magnet structures may be approximated by use of cylindrical harmonics and use of magnet vector potential.[1] The structure using coils of zero width may be approximated by use of cylindrical line charges, and by interchanging lines of force and equipotentials. For other coil widths, the field may be approximated by using a Fourier analysis on the ring surface.

Strictly, the cylindrical harmonics assumption is invalid since the magnetic element is short compared to its radial dimensions. However, since the method yields scale plots very similar to those found in actual instruments, the assumption is justified. Figs. 2, 3, and 4 are typical field plots, and Fig. 5 shows the predicted scales corresponding to the fields. Figs. 2 and 5A are for a magnet movement. Figs. 3 and 5B are for a zero coil length wattmeter. Figs. 4 and 5C are for a 45-degree coil length wattmeter. Actual scales for movements having field conditions similar to those used to determine the scales in Figs. 5A and 5C are shown in Figs. 11A and 11B.

As can be seen from the field plots and instrument drawings, the magnetic system is of a large enough size and clearances that an instrument technician can change the path reluctance in small areas in order to vary the scale calibration to fit his requirements. The technique consists of placing a magnetic shunt, as indicated from A to A in Fig. 4. If this shunt is inserted, the flux is increased in the neighborhood of A and A, altering the scale as shown. Since the shunt will seldom approach closer to the ring than 0.1", variations of scale calibration by as little as five percent require changes of gap of five percent of 0.1", or 0.005". As a result, adjustments of scale reading are possible without having to work to tolerances of tenths of thousandths of an inch. Such adjustments therefore could be done by relatively simple techniques and tools. At present, these corrections are made by individual calibration, because modification of the magnetic system is extremely difficult to perform to tolerances required on standard types of movements.

The dynamic analysis of this movement (as of other movements) can be studied by use of Lagrange's equations and operational calculus or any other convenient method. The mechanical systems for the common commercial movements, as well as for this development, have the same simplified form. Their differences are in the distribution and magnitude of masses.

Analyses were made of three arrangements of the mechanical parts. The first consisted of a study of impact shock on the standard movement form, namely a pivot system carrying the firmly-mounted mass of the movement, with an additional mass sprung to the pivot mass. Although this is a considerable modification, the concentration of all the sprung parts in one stiffly-coupled mass represents the worst possible condition. The second form of the equations included an elastic pivot point assumption. The third analysis assumed a spring-loaded elastic pivot cup. In this case the impact force between the pivot and cup was studied.

The mode of attack was unusual in one respect. A unit change of velocity, rather than the usual unit change of force, was applied to the mechanical system mathematically. This method was chosen as the forces are greatest under this condition. Use of the Duhamel integral would convert this velocity function to any other form which might be needed.

Fig. 6A shows the mechanical layout for the first analysis, and 6B for the third. Definitions and methods of solution used are found in Appendix 2. The final shock force equation for the simple equivalent movement, case number one, is:

$$F_x = M_1 p V_x 1 + M_2[(K/M_2)]^{\frac{1}{2}} V_x \sin[(K/M_2)^{\frac{1}{2}}t] \qquad (2)$$

For the sprung pivot cup solution, case number three, the final equation is

$$f_y = M_2[K_1/(M_1+M_2)]^{\frac{1}{2}} V \sin[(K_1/(M_1+M_2))^{\frac{1}{2}}t] + [K_2 M_3]^{\frac{1}{2}} V \sin[(K_2/M_3)^{\frac{1}{2}}t] \qquad (3)$$

These equations show the validity of a number of significant points. It is evident, for instance, that a rigidly-supported mass undergoes very high stress. Under theoretical conditions,

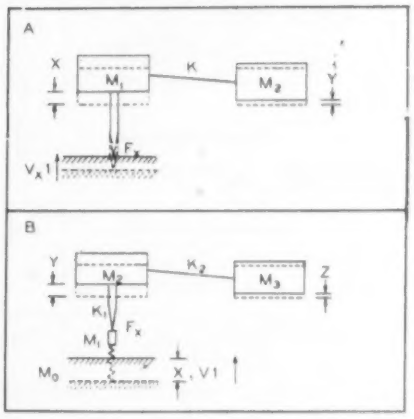


Fig. 6

this force is infinite. Actually it is the product of the rigid mass by its acceleration. For this reason, reduction of both the rigidly-coupled mass and the velocity rise would reduce the stress. The application of this can be seen in the discussion of the resulting mechanical design which follows.

In addition, it can be noted that in the case of elastically-coupled masses, the forces depend approximately upon the square root of the product of the coupling stiffness by the coupled mass. Hence, the lower the stiffness and mass, the lower the resulting stress.

In order to prevent permanent deformation of the movement, the peak magnitude of forces must be limited to a rather low value. This applies an additional constraint to the problem. With the proper design, at points where high stresses might occur, stronger portions of the movement assembly would have to carry the element in question and thereby prevent damage.

The Resulting Mechanical Design

The development of the movement of new design, along the lines already indicated, brought to light a number of interesting features. The new design violates accepted practice in many respects, yet it has proved to be mechanically rugged.

The force equations indicated it advisable to minimize the mass at the pivots. Since the coils normally are located at a distance from the pivots in this new design, the pivot mass is low. Furthermore, in the design, this mass is further reduced by use of a spring structure between the two pivots. Because this spring is stiff, it maintains normal spacing against gravity and vibration. However, under shock, the spring will give, isolating the two pivots and further lowering the coupled mass.

The pointer mass is small because the pointer itself is a short extension of one of the coils. As a result, deformation is unlikely. Coupling the upper assembly to the lower by way of a spring as in Fig. 7C makes further use of these design criteria. In a movement having a distorted scale, this is of extreme importance since small errors in

*The three mathematical appendices are omitted from this issue of *Instruments* but will be included in the reprints. Reprints will be obtainable from the Johns Hopkins University, Baltimore, Maryland.

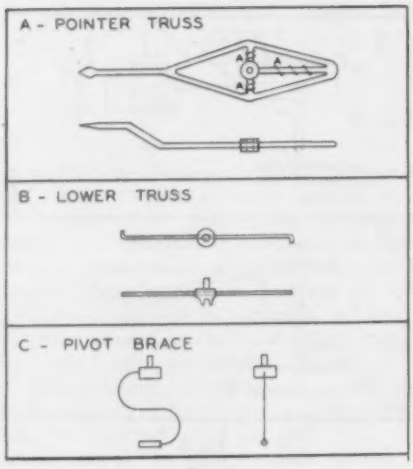


Fig. 7

positioning completely destroy the accuracy of calibration. From Equation (1) it is seen that where $\delta\beta$ depends on θ, $T = \delta\beta\, 2\,n\,i\,l\,r$. If $\delta\beta$ is constant, then the torque is proportional to the current. If it is not, $T/\delta\beta$ is proportional to the deflecting current. In this case, the scale calibration is only true if the relative position of deflecting element and pointer is maintained. The error $i(\theta)$ against $i(\theta+\theta_o)$ resulting from such an assumption in a somewhat exaggerated case is shown in Fig. 13, which is supplemented by a mathematical study in Appendix 3.

A movement of the sort indicated naturally requires bracing in order to function properly. This bracing should be able to resist the effects of gravitational deformation, and, at the same time, be sufficiently flexible to permit the shock-relieving properties. If the coil assembly structures which carry the pivots consist of one diamond-shaped truss (Fig. 7A) and one wire spacer (Fig. 7B), the coils themselves will be fixed securely in their proper position. If the balancing weights, AA, are carried on three arms of the cross-shaped structure in the diamond (Fig. 7A), they will have adequate support and therefore will not shift under stress. In order to be able to make use of a movement having heavy masses (the coils) sprung from the supports, adequate provision for bracing these masses under shock is necessary to prevent damaging the elastic members. This is possible in the movement described, as the coils can be built to have extremely small clearances with the magnetic ring. The ring then can supply the required support under shock. As a result of these factors, the movement itself has excellent internal bracing and is able to withstand a considerable stress without damage.

Since Equations (2) and (3) indicated the desirability of limiting the total pivot-pivot cup mass, possibility of further reduction of the mass was considered. Such a reduction was obtained by recalling the technique of suppressed-zero type of instrument movements. A cross-sectional sketch of a type of pivot cup including this feature is shown in Fig. 8. The actual pivot cup is mounted in as small a holder as possible, and held against the cup end cap with a spring. This spring is made just strong enough to be able to press the cup against the cap with full movement weight against it. The cups built weighed five milligrams. As a result of the light spring and the small cup mass, the possibility of damaging either pivot or cup becomes almost infinitesimal. As can be seen, these cups act as normal cups except under shock.

The only way in which the group stresses affecting a given movement as a whole can be lowered is through the reduction of acceleration. It is feasible to mount the whole of this movement on stiff springs because its mechanical structure, with the exception of the

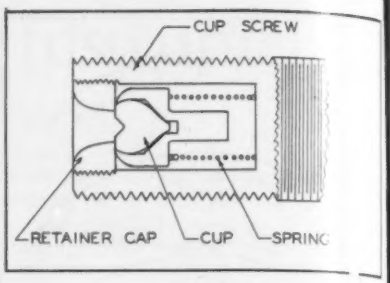


Fig. 8

pointer and its balancing weight, is mechanically completely symmetrical with respect to the rotational axis of the movement. Use of such springs lowers the peak acceleration of the movement, and offers some additional improvement of shock properties to the movement.

Advantages

As can be seen from the discussion of its various features, the movement should have improved properties compared to existing units. That this is the case is evident from the following review of experimental results.

From a mechanical point of view, the design proved to have ample rigidity under non-shock conditions. No deformation of the movement could be detected on shifting the movement to the various possible mounting positions; and, once balanced, the movement remained balanced, even after the shock of being dropped to the floor several times from the height of five feet. Since the first indication of deformation would be a destruction of the movement balance, the unit shows itself to be mechanically rugged.

The weights of the movement parts in this instrument compare favorably with those of the d'Arsonval, repulsion iron and dynamometer movements. A classification of weights of typical designs is given in Table I. From this

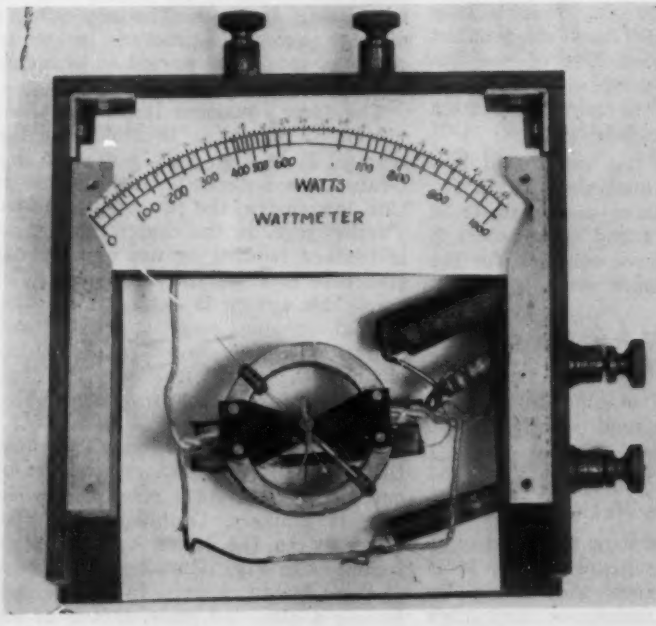


Fig. 9

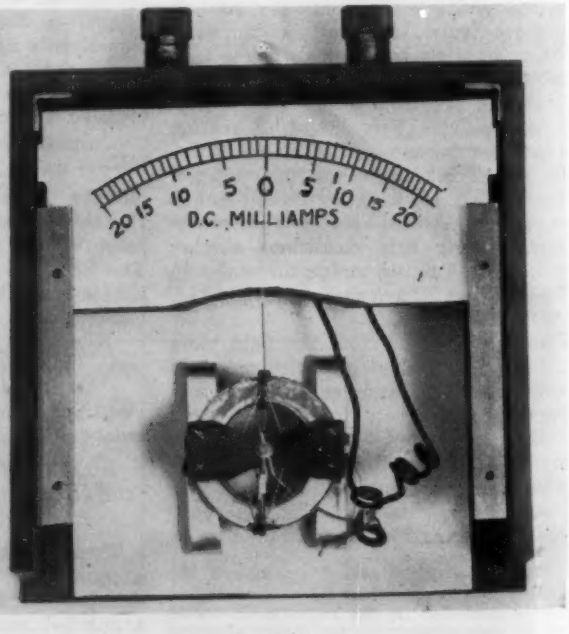


Fig. 10

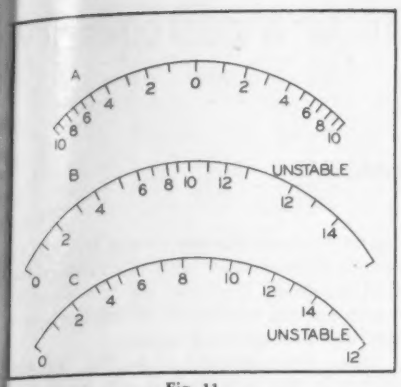


Fig. 11

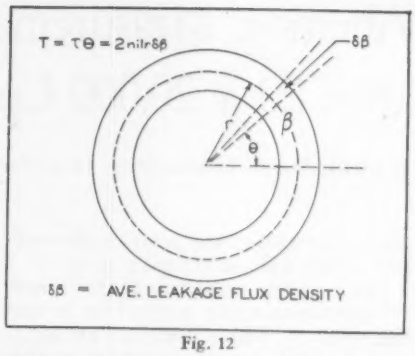


Fig. 12

Table I. Comparative Weight Distributions in Milligrams for Typical Movements

Part	New Movement	D'Arsonval	Repulsion-Iron	Dynamometer
Pivot Assembly	20 32	20	60	60
Deflecting Element	160	100	215	180
Pointer System	90	25	25	25
Springs	80	60	25	50
Rigid Mass				
Upper Pivot	40	150	215	200
Lower Pivot	35	140	205	190
Sprung Mass				
Upper Pivot	342	70	110	115
Lower Pivot	347	80	120	125
Total Mass	382	220	325	315

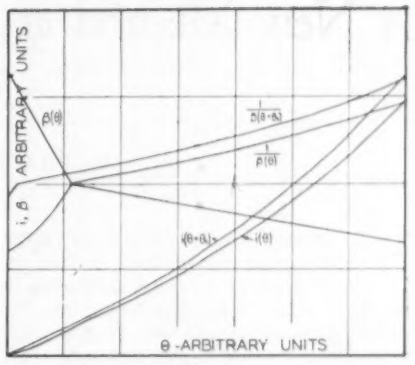


Fig. 13

table it can be seen how the new design fulfills the requirements called for by the mechanical study.

The periods in the sample movements were one-third second and one-half second respectively. The torque constant of each spring used was 50 dyne-centimeters per radian. With a movement total mass of 392 milligrams in this instrument, the torque per unit weight is 255 dyne-centimeters per radian per gram. This value can be high for two reasons. One is that the lever-arm produces increased deflecting torque for the same weight. The second is that a larger share of the total mass is effective in producing torque than in the usual design. The pointer assembly frames offer a much smaller contribution to the movement inertia than in the standard movement design. This results from the fact that the radius of gyration in this movement is 2.5 times that of a d'Arsonval movement. For the same coil weight, the coil inertia is 6.25 times that of the d'Arsonval. Since the period of these movements is slightly less than that in equivalent-size instruments used commercially, the inertia resulting is not excessive. Instruments of equivalent size usually have a torque constant of between 50 and 60.

Electrically, the movement showed improvement in sensitivity. The wattmeter (Fig. 9) had a potential circuit power loss of 0.7 watts, and a current circuit loss of 0.2 volt-ampere. This is a good improvement over 4 watts and 0.7 volt-ampere of the dynamometer wattmeters of equivalent characteristics. As an a-c. milliammeter of 50-ma. full-scale current, the movement had a power consumption of less than 0.115 va. as against a power consumption of 0.45 va. in a repulsion-iron instrument of equivalent properties. As an a-c. voltmeter, a similar improvement exists.

The magnet form of the movement shows the same order of sensitivity as the d'Arsonval movement. If the conversion of characteristics to equivalent conditions is carried out, the watts consumption in equivalent units is about 500 microwatts. This movement is shown in Fig. 10. Its scale is shown in Fig. 11A.

Experiments on the alternating-current form of the movement confirmed that ease of modification of scale could be obtained in this design. The magnetic shield for the movement can be employed very simply to shield the external fields and to provide lower reluctance paths for the magnetic flux at those places where sensitivity is low. The two scales shown in Fig. 11B and 11C indicate the variation of sensitivity obtainable with an extremely simple U-shaped shunt. A uniform field, then, is achieved by adjusting the shield so that it holds the reluctance of the various paths constant.

Conclusions

It is evident the new type of movement offers a number of distinct advantages over existing instruments. Mechanically, it has been designed to have ample rigidity, and good resistance to the damaging effects of shock and vibration. It has a high torque-to-weight ratio (255 dyne /cm./rad./gm.) with the resulting desirable characteristics. Electrically, it offers substantial improvement in sensitivity over the existing alternating - current instruments of the repulsion-iron and dynamometer types. As a wattmeter, the power consumption is extremely low, and power factor compensation can be made very simply since the inherent error is extremely small. As both an alternating-current voltmeter and milliammeter it offers increased sensitivity.

The new movement also lends itself readily to modification of scale characteristics. Since the pointer is short and can be braced stiffly on the movement, unorthodox calibration curves can be maintained in the face of hard usage. As a result it is practicable with this movement to build instruments for severe vibration and shock conditions with calibration to suit the user.

Acknowledgments

The writer is indebted to the faculty of the Johns Hopkins University, Baltimore, Maryland, and in particular to Dr. W. B. Kouwenhoven, Dr. R. H. Cox, and Mr. T. Larsen for their untiring guidance in the study of this problem. In addition he is indebted to the faculty of the California Institute of Technology, Pasadena, California, and especially to Dr. F. W. Maxstadt, Dr. F. C. Lindvall, and Dr. W. R. Smythe for assistance in preliminary studies on this movement. In addition, he wishes to express his appreciation to Mr. Irving Weinstein and Mr. Richard S. Davis for invaluable assistance in solution of mechanical construction problems.

Reference

(1) W. R. Smythe, "Static and Dynamic Electricity," McGraw-Hill Book Co., 1940; page 429.

Modern Cold-rolling-mill Instrumentation

(SEE COVER PHOTO)

Over-all view of the five-stand cold-reduction mill, the "heart" of the new sheet and tin mill of Columbia Steel Company, in Pittsburg, California, recently placed in operation by this United States Steel Corporation subsidiary. Instruments on the panels at the various stands of the mill provide the operators with continuous indication of operating conditions. Controls on the panel at the first stand in the foreground include the push-buttons for operation of the screwdowns, and other buttons for signalling. The panel at other stands include indicating instruments, also control instruments for governing mill speed, gage of the product being rolled, tension, and control of screwdown position. Finishing speed of this huge unit is about 3900 fpm. Previously pickled coils of flat-rolled steel pass continuously through the five rolling mills, and emerge at the opposite end reduced to the desired thickness for further processing.

A New Method *of* Vibration Measurement *for the* Frequency Range 20 *to* 20,000 Cps.

By FRANK MASSA, Massa Laboratories, Inc., Cleveland, Ohio

BASIC requirement for a good vibration-measuring method is that it shall produce an exact facsimile of the mechanical vibration being investigated. Because of the fact that the vibration of a point has direction as well as magnitude, it is important that the method's primary element—the accelerometer unit—respond only to the vector component of a vibration imparted along a predetermined axis of the structure. In addition to having this unidirectional sensitivity characteristic, the accelerometer should be free of resonances within its entire operating frequency range and it should also have uniform phase shift between the mechanical vibration and its electrical output over the entire frequency range, otherwise transient vibrations would be distorted. Of course, a good vibration measurement instrument should also be rugged and stable with

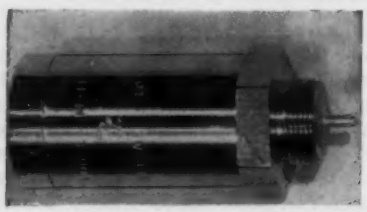


Fig. 1. Accelerometer unit.

time and its operating characteristics should be independent of any day-to-day changes in the environment under which it is used. The linearity of the instrument should cover a large dynamic range to avoid distortions in the measurement of large amplitudes.

In order to achieve these objectives for a frequency range up to 20 kc., the new method described in this article employs an accelerometer unit designed so that its electromechanical system has a single degree of freedom and it is stiffness-controlled to beyond 20 kc. This insures both smooth response and uniform phase shift between the mechanical vibration and the generated electrical voltage over the entire frequency range. The unit (Fig. 1) consists of an assembly of several ammonium di-hydrogen phosphate crystal plates mounted within a stainless steel housing approximately 1" diameter 2" long. The crystal assembly is so arranged that a stress is imparted along the piezoelectrically-sensitive axis of the plates only in proportion to the component of mechanical vibration which exists along the normal geometric axis of the cylinder. For vibrations imparted to the structure in any direction in a plane normal to the axis of the cylinder, the output of the unit is virtually zero.

The complete embodiment of the new vibration-measuring method is a system (Fig. 2) which includes: an accelerometer, a mounting fixture which may be rigidly bolted to the vibration structure under test, a flexible length of shielded cable for connecting the signal from the mounting fixture (which also serves as a socket connector) to the preamplifier input socket, a preamplifier, and a battery-operated power supply unit. The preamplifier is assembled in a stainless steel cylindrical housing 1-¾" diameter by 6" long, fitted with a hook-eye for hanging with a rubber band for isolation purposes when necessary. Two 25-ft. cables come out from the base of the preamplifier to permit remote location of the power supply unit and the external indicating or recording equipment. The mounting fixture is equipped with a 3/16" diameter copper U-shaped tube soldered into its base so that cold water may be circulated through the fixture when it is attached to hot vibrating structures.

Operating Characteristics

The accelerometer is designed so that its mechanical system is a pure stiffness and its electrical impedance is a pure capacitance over the entire operating frequency range up to 20 kc. These simple relationships achieved in the design of the electromechanical system, coupled with the use of ADP crystal in its simplest compressional mode of vibration, insure complete freedom from phase distortion in the reproduction of any transient phenomenon having components in its wave-shape as high as 20 kc.

The dynamic range of the complete equipment is limited by the amplifier and not by the accelerometer because of the absence of non-linear distortion in ADP crystal up to extremely high stresses (more than several hundred pounds per square inch).

The simplicity and ruggedness of the design make the accelerometer effectively equivalent to a primary standard, since its absolute characteristics may be computed from the piezoelectric and physical constants of the assembly. The theoretically computed characteristics were experimentally substantiated for a group of units within the limits of accuracy of making the measurements (approx. ± 5%). Another indication that this unit behaves as a simple mechanical vibrating system was evident from the uniformity obtained in the experimental calibration of a group of twenty-four equipments manufactured for use by the U.S. Navy which showed that both the mechanical and acoustic response of the various units agreed within ½ db of the average for the entire group.

The arrangement of the crystal plates in the acceleremeter is such that for constant acceleration applied along its longitudinal axis, constant stress occurs along the piezoelectrically-sensitive axes of the crystal elements which results in a generated voltage directly

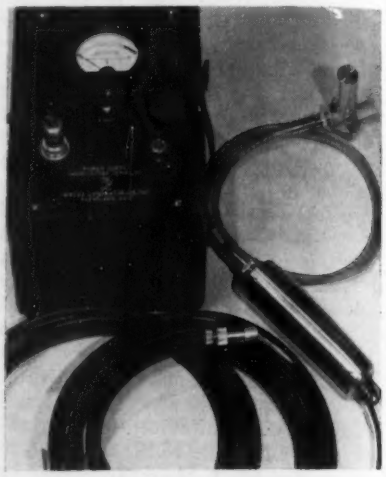


Fig. 2. Vibration measurement equipment.

proportional to the acceleration and independent of frequency. Fig. 3 shows the acceleration response of the accelerometer for vibrations applied along its normal axis. The dotted curve shows the sensitivity at the low-impedance output terminals of the preamplifier. Figs. 4 and 5 show the velocity and amplitude response characteristics of the accelerometer for vibrations occurring along its normal axis. It is well-known that particle velocity and amplitude are related to acceleration as a function of frequency and frequency squared, respectively, so that the curves in Fig. 4 and Fig. 5 are related to Fig. 4 in this same way. If it is desired to have the measuring circuits indicate constant output as a function of frequency for either velocity or amplitude measurements, it is merely necessary to introduce a 6 db/octave or 12 db/octave high-frequency loss in the measuring circuit, which will accomplish the desired objective.

When the direction of vibration of the structure under test is known, the absolute magnitude of the vibration may be obtained by mounting an accelerometer with its normal axis in line with the direction of vibration. When

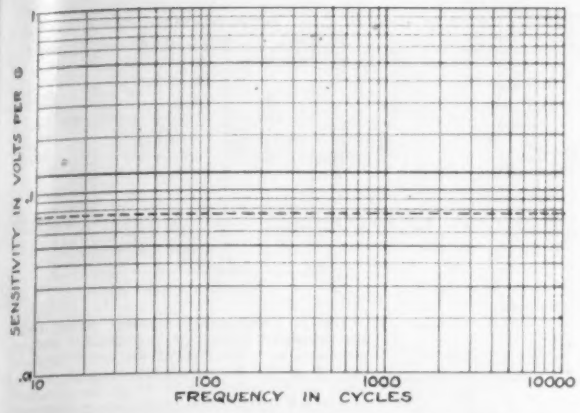


Fig. 3. Acceleration response of the accelerometer. The dotted curve shows the sensitivity across the low-impedance output terminals of the preamplifier.

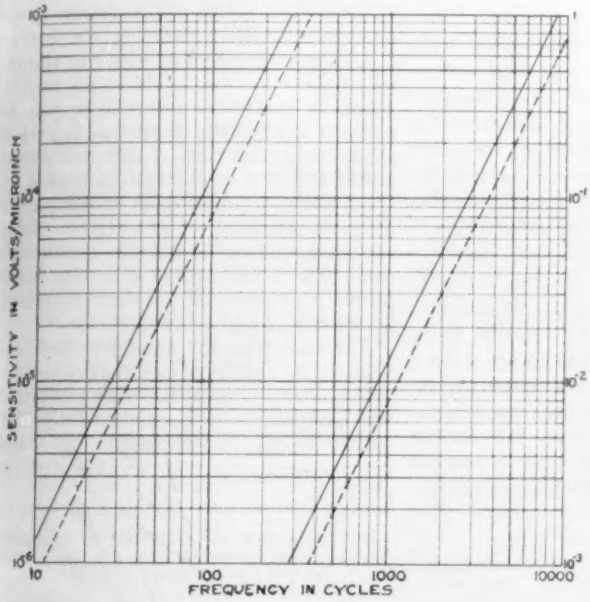


Fig. 5. Amplitude response of the accelerometer. The dotted curve shows the sensitivity across the low-impedance output terminals of the preamplifier.

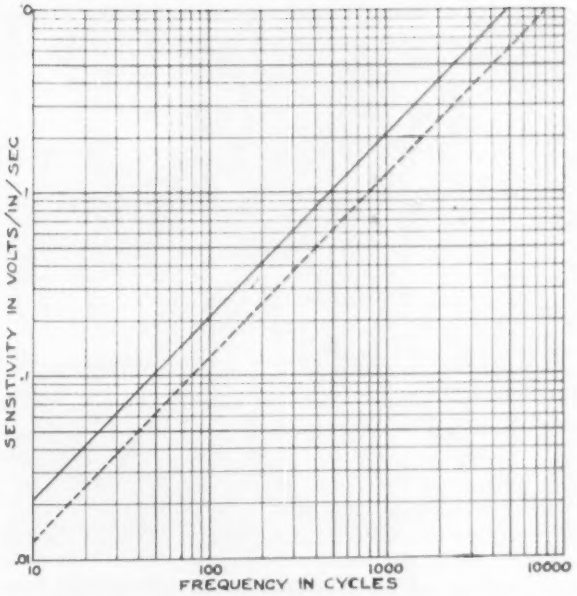
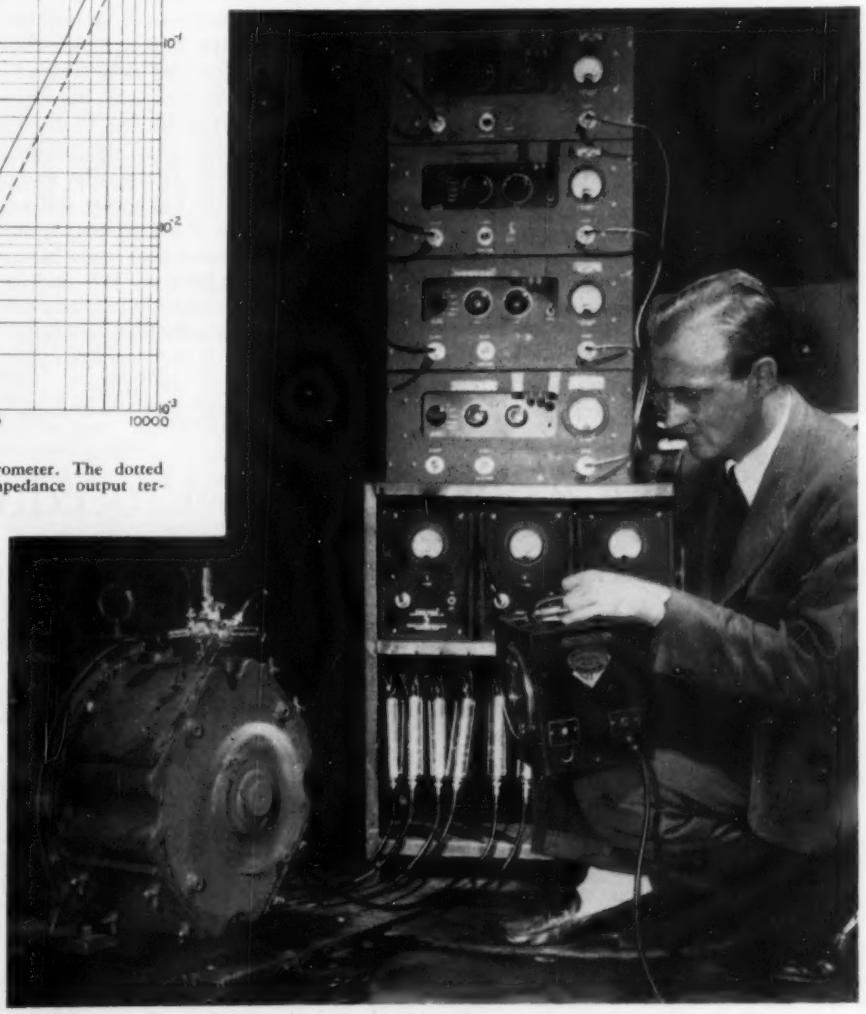


Fig. 4. Velocity response of the accelerometer. The dotted curve shows the sensitivity across the low-impedance output terminals of the preamplifier.



SHOWING NEW METHOD IN ACTUAL USE.—A group of three accelerometers (top of motor, foreground) in tri-axial orientation. *(Official Navy Photograph taken at U. S. Naval Engineering Experiment Station, Annapolis, Md.)*

the direction of vibration of the structure is unknown, the true vector magnitude in space can be established by mounting three accelerometers mutually perpendicular and making simultaneous measurements of the response of each channel. The vector sum of the three readings will give the magnitude and direction of the vibration.

Although the equipment described was designed basically for making vibration measurements over a very wide frequency and dynamic range, its construction is such that it may be also employed for making accurate sound pressure measurements. The free-field response of the accelerometer when used as a microphone is shown in Fig. 6. The inherent electromechanical linearity of the structure to high intensities permits the measurement of extremely high magnitudes of sound pressures such as may be encountered in gunfire.

When making vibration measurements corresponding to accelerations as high as approximately 100 *g*, the amplifier input circuit will begin to overload. To extend this overload point to approximately 1000 *g*, a times ten multiplier is available for insertion at the preamplifier input socket. The lowest values of vibration magnitudes or sound pressures that can be measured are determined by the thermal

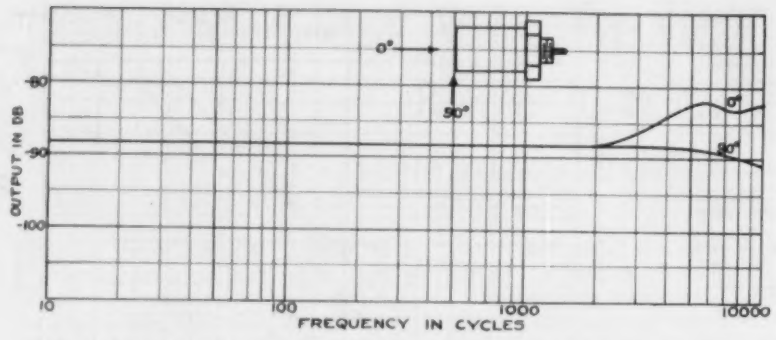


Fig. 6. Free-field response characteristic of the accelerometer when used as a microphone.

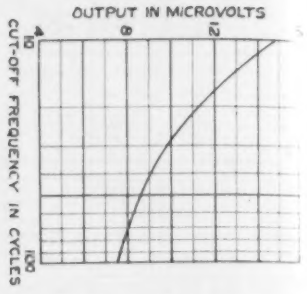


Fig. 7. Total r.m.s. thermal noise voltage measured across the preamplifier output terminals as a function of the low-frequency cut off of the output circuit (cut off is defined as the frequency at which the response is down 3 db). The high-frequency response of the amplifier is flat to 100 kc.

noise generated in the preamplifier. Fig. 7 shows the total r.m.s. thermal noise voltage as measured across the output terminals of the preamplifier with the high-frequency range extending flat to 100 kc and the low-frequency range cutting off as indicated in the chart. By comparing the noise voltage shown in Fig. 7 with the various sensitivity characteristics indicated by the dotted lines in Figs. 3, 4, 5, and 6, it is easy to determine what minimum values of acceleration, particle velocity, amplitude or sound pressure are needed to override the thermal noise present in the amplifier. If single-frequency measurements are to be made, the use of band pass electrical filters ahead of the measuring circuit will greatly reduce the threshold below the values determined above for wide-band amplifier response.

Applications

Among the uses of this new method is the analysis of vibrations in high-speed turbines, gear trains, and machinery, including the analysis of their mounting structures for the quantitative investigation of the degree of isolation offered by various designs. The wide-range response of the method will permit the measurement of high-order harmonic components of the vibration which may be of considerable importance in the investigation of internal sources of machinery noises. Another important use is in the analysis of machine mounts for the detection of any high-order harmonics that may be transmitted from the source through the mounts. Limited range equipment would not reveal this information and, in the silencing of ships' noises radiated into the water, for example, it is of extreme importance that wide-band analyses be made because low-amplitude high-order harmonic vibrations of structures may generate high-intensity underwater sounds if they are not completely isolated from the hull.

One interesting use of this new method has been in calibrating the wave-shape generated by vibration tables such as the dynamically-driven force generators. By presenting the output from the accelerometer which is clamped to the vibrating table to an oscilloscope, a continual observation can be made of the generated mechanical wave shape as a function of frequency and amplitude and limits can be placed on the maximum amplitudes vs. frequency to yield sinoidal vibrations. Some rather surprising amplitude limitations were found necessary, even for high-power vibrators, if sinoidal vibration is desired at higher frequencies.

The fact that the accelerometer also behaves as a wide-range rugged sound-pressure microphone has also permitted the equipment to be successfully employed in the measurement of sound pressures generated by gunfire and explosions.

The accelerometer described in this article has been manufactured for the Navy, but is not yet commercially available.

Apparatus and Procedure for Testing Pyrometer Switches*

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IT is common practice to connect a number of thermocouples to a common indicating instrument—usually a millivoltmeter—by means of a multi-position selector switch. The accuracy and reliability of any pyrometric system are no better than that of its componets; thus, a switch unit that will give positive and reliable operation and have a reasonable life expectancy is a necessity. The switch must provide reliable mechanical and electrical performance under extreme operating conditions of heat and moisture.

The efficient electrical performance of the switch is of utmost importance because of the small operating power available in the system. Navy Department Specification 17-I-23 covers the use of iron-constantan thermocouples in the measurement of temperatures up to 1200°F. At this temperature an I-C couple will develop a maximum emf. of approximately 36 millivolts (0.036 volts). With this voltage, the current in a pyrometer system is less than 0.5 milliamperes. Therefore, the voltage drop across the multi-point switch contacts is of utmost concern. It is impractical to determine by ordinary voltage readings the extremely small contact drop that normally occurs at the switch contact. This is especially true where numerous repetitive measurements of this voltage drop must be made under various conditions of test to determine the suitability of switch design. Therefore, a simple method has been devised for evaluating the electrical suitability of a switch for use in pyrometer systems. The method is based on simulation of actual operating conditions.

The test circuit, Fig. 1, consists of a primary and a secondary branch. The primary branch comprises a 6-volt storage battery as a power source across which are connected in series with a 1-ampere ammeter, a 25-ohm control resistance, a 1-ampere 50-millivolt instrument shunt and a switch. This circuit provides a low-impedance source of variable test voltage. The secondary branch consists of the switch under test in series with an 80-ohm resistor, a 1-ma. precision type milliammeter (18.4 ohm internal resistance), and a 50-millivolt instrument connected across the instrument ter-

*The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official or reflecting the views of the Navy Department or Naval Service at large.

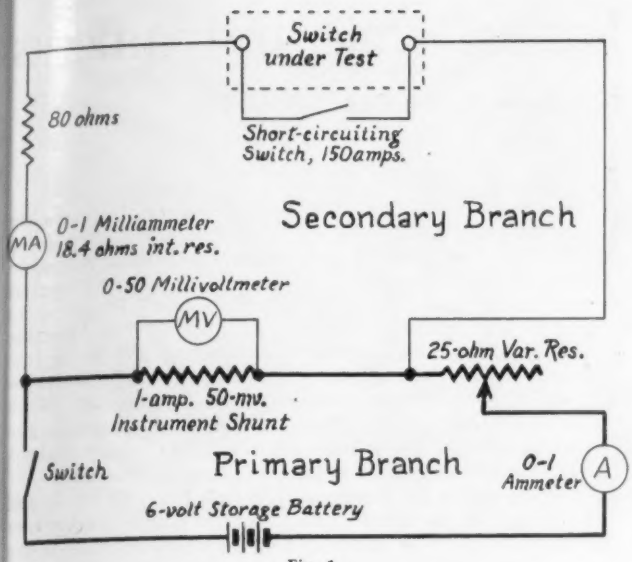


Fig. 1

Fig. 2

minals of the shunt which is a source of regulated test voltage for the secondary branch. In addition, a heavy duty knife switch, of at least 150-ampere rated capacity, is shunted across the terminals of the switch under test by means of heavy conductors of at least number 8 gage. In the test procedure, this switch functions as a short-circuiting means for the multi-point switch under test. The total resistance of the secondary branch is thus approximately 98.4 ohms. *This is the equivalent circuit resistance of the average pyrometer system.*

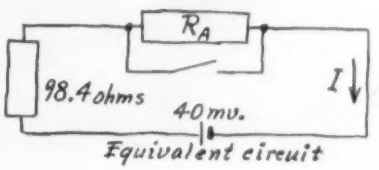
With the switch under test connected in the circuit as indicated in Fig. 1, the variable resistance in the primary branch is adjusted to provide test voltages of approximately 10, 20, 30 and 40 millivolts in the secondary branch. Two observation readings are made on the milliammeter for each test voltage setting, one with the short-circuiting switch initially closed and the other with this switch opened. In reading the milliammeter, an inexperienced observer can readily detect a difference of 0.002 ma. (two microamperes). With a little experience a change of one microampere can be detected. When the switch under test produces a current change of one microampere in the secondary branch, as determined by the closing and opening of the short-circuiting switch, a switch contact drop of 0.097 millivolts is indicated out of a total of 40 millivolts test voltage. This contact drop amounts to a 0.28% error at the 1200°F. point in a temperature indicator of a pyrometer system. The corresponding effect at the 600°F. point will be a 0.56% error. (See appendix for calculations.)

The procedure followed in determining the suitability of a pyrometer switch involves various tests. A determination is first made of the switch contact drop for the initial received condition at ambient temperature. Tests are then made to determine the effect of temperature extremes (0°C. to 65°C.) on switch performance. The switch is then subjected to a vibration test cycle. Finally, the switch is subjected to an accelerated operating test to determine life expectancy. A measurement of the electrical characteristics is taken after each test by the procedure previously outlined. The Navy Department Specification 17-S-18 on thermocouple switches outlining these test procedures requires that no observable change in current shall occur when short-circuiting switch is opened. This means that, with 40 millivolts applied in the secondary branch, the switch contact drop is less than 0.097 millivolts. In addition, in all stages of the test, any mechanical difficulties or failures are noted.

The test method for contact drop presented above allows for the ready observation of any relative changes in the switch contact drop throughout the various test stages independently of variations in the circuit constants and variations in the measuring instruments caused by ambient temperature changes. This method also eliminates the errors caused by the inability to exactly duplicate test-voltage settings in the course of the repetitive readings in the various test stages. Under usual conditions of small switch contact drop, these errors are frequently large enough to impair the validity of the test results when more direct methods, using measurement of total circuit current, are employed. The presented method is simple and does not require specialized laboratory equipment or specially trained personnel. To adapt the method to any temperature limits or thermocouple constants, the circuit elements can be changed and the applied secondary branch test voltage adjusted accordingly.

To facilitate the test procedure, the test circuit is arranged in a permanent set-up with all necessary connections brought out to terminals on a panelboard. The short-circuiting switch is mounted on the test bench. The terminals are marked with appropriate designation nameplates. In addition, the instrument connection terminals are marked with the instrument identification numbers to insure the use of the same instruments in all the tests. The test set-up is shown in Fig. 2. Although this apparatus was originally designed and developed primarily for the testing of pyrometer switches, it can be used to indicate the contact drop of other types of switches or devices where the current is in the order of 0.5 milliamperes. An example of the use of this test procedure is a "Go-No Go" test for the production testing of switches.

Appendix



R_N = New total circuit resistance with change of 0.001 ma.

I_N = New current with minimum detectable change of 0.001 ma.

R_A = Added contact resistance for 0.001 ma. change

$$I = \frac{E}{R} = \frac{40 \times 10^{-3}}{98.40}$$

$$= 0.4065 \times 10^{-3}$$

= amperes (with no contact drop)

$I_N = 0.4065$ ma. $- 0.001$ ma.

$= 0.4055$ ma.

$$R_N = \frac{E}{I_N} = \frac{40 \times 10^{-3}}{0.4055 \times 10^{-3}}$$

$= 98.64$ ohms

$R_A = 98.64 - 98.40 = 0.24$ ohm

Voltage drop $= 0.24 \times 0.4055$

$= 0.09732$ mv.

Operation *and* Care *of* Circular-scale Instruments

By JAMES SPENCER, Meter Division, Westinghouse Electric Corp., Newark, N. J.

PART V

SYNCHROSCOPES

When the load taken from an alternator is shared by another machine connected in parallel, certain conditions must be met before the two machines are tied together. The voltages of the two machines must be equal and in phase, and the frequency of the two circuits must be the same. The circular-scale synchroscopes (see Figs. 13, 14, 15 and 16) are instruments for accurately detecting and indicating these conditions on a carefully calibrated scale to show the point of synchronism or the relative difference of synchronism (fast or slow) between the two circuits.

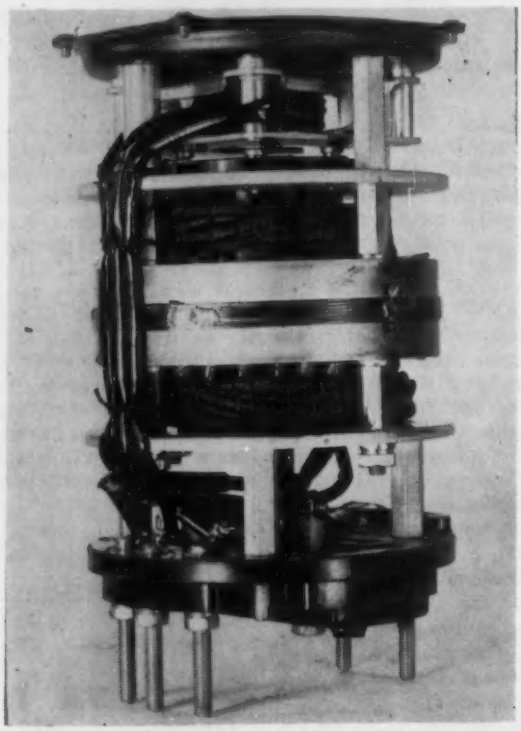


Fig. 13. Westinghouse KI-24 synchroscope with cover and case removed.

The pointer position of the synchroscope indicates the instantaneous phase relation of the two machines being paralleled. The speed of rotation of the pointer is proportional to the difference in frequency of the two machine circuits and by its direction (fast or slow) indicates the speed of the incoming machine with relation to the running machine. When both circuits have equal frequency, the pointer will give a stationary indication equal to the angular difference in phase relation of the two circuits. When the two circuits are in phase, of the same frequency and equal in voltage, the pointer will take a stationary position directly over the dummy pointer marking on the dial.

The circular-scale synchroscopes (see Figs. 13, 14, 15 and 16) operate on the same principle as the single-phase power factor meter. Their rotating field coil arrangement is the same and their phase-splitting device (see Fig. 5) is similar. The synchroscope differs from the power factor meter, however, in that its polarizing coil is designed for voltage application while that of the power factor meter is for current application.

The anti-creep mechanism of the KI-24 synchroscope serves to prevent the iron vane from following the rotating field when the running machine only is connected.

INSPECTION AND TEST

The first step in the calibration of the KI-24 synchroscope is to balance the voltages across the stator windings. With the instrument in the face-up position and connected as shown in Fig. 17, full rated voltage should be applied and equalized (within plus or minus two volts) under the following conditions:

1. Voltage across *A-B* with pointer in the 12 o'clock position.
2. Voltage across *B-C* when the pointer is rotated 120 degrees clockwise from the 12 o'clock position.
3. Voltage across *C-A* when the pointer is rotated 120 degrees counter-clockwise from the 12 o'clock position.

The equalization of voltages is made by varying the resistance and changing connections on the reactor taps until a combination is found to give the desired results.

The instrument is next checked for creep; and anti-creep adjustment made if necessary. The instrument is set in the face-up position for this test and rated voltage is applied to the running machine circuit only. If creep is present, the resistance *X* (See Fig. 18) should be adjusted to overcome this fault.

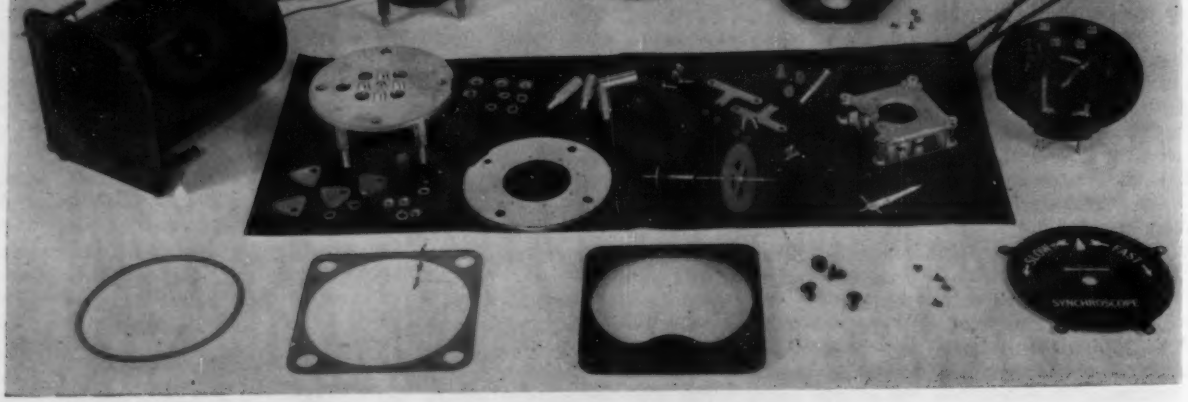


Fig. 14. The Parts of a KI-24 Westinghouse synchroscope.

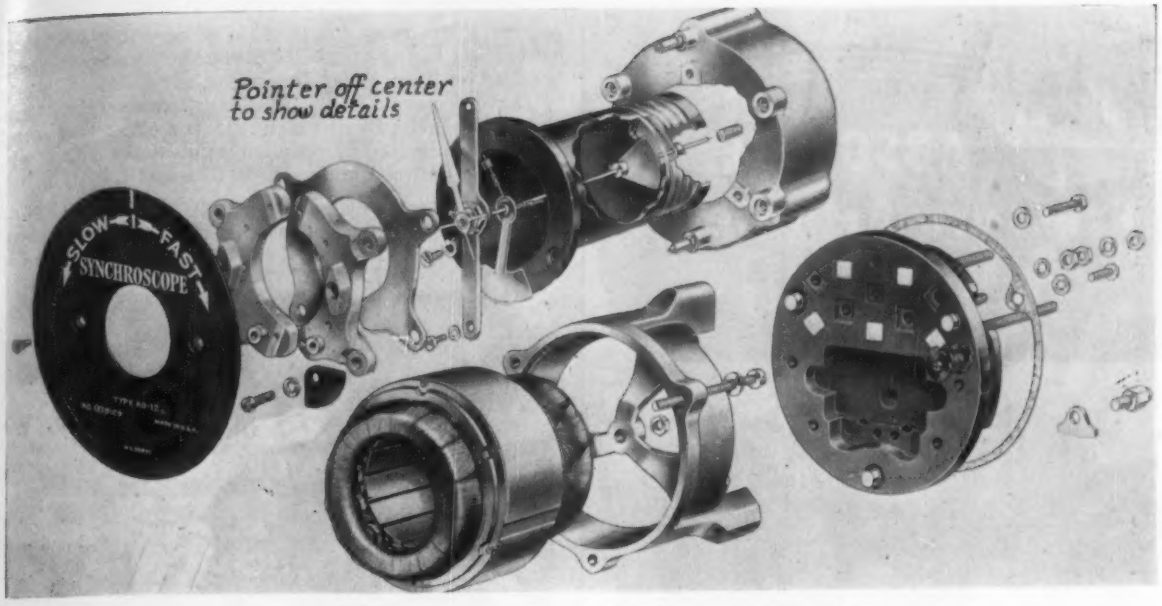


Fig. 15. Exploded views show details of General Electric AB-12 synchroscope.

With the instrument still in the face-up position, both the incoming and running machine circuits are energized from the same source and the pointer is set at the synchro-

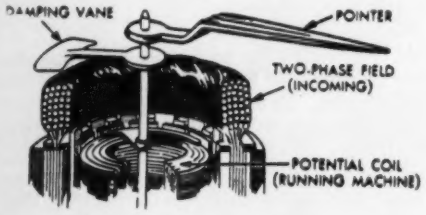


Fig. 16 Construction details of the General Electric AB-12 snychroscope.

nous point (12 o'clock position). The pointer shift is made by loosening the set screws on the pointer hub, moving the pointer to the desired position and retightening the screws. The instrument is then placed in its normal operating position, the voltage reduced to fifty percent of rated value and the element balanced to be within one degree of the synchronous point when in the normal position and when rotated 90 degrees in either direction.

The instrument is now connected as in Fig. 17 or 18 and the rotation pull-in value and hold-in point checked. The rotation should be even and in the fast or slow direction according to how the incoming machine is varied either raised or lowered. If the calibration is made correctly and the instrument parts are not deranged or defective, the pointer should start rotating when the frequency is within two cycles either side of normal and should hold in up to two and one-half cycles either side of normal.

In the AB-12 synchroscope each branch of the split phase circuit is balanced so that at rated voltage and frequency the currents in each side of the circuit are equal.

The instrument is then connected as in Fig. 19 and the pointer set in the 12 o'clock position. To shift the pointer, the set screw in the pointer hub should be loosened, the pointer moved and the set screw retightened.

The element should next be balanced to assure even rotation of the pointer. After balance the instrument should again be connected as in Fig. 19 and the bucking or 12 o'clock position rechecked and reset if necessary.

Maintenance

Owing to the importance of calibration of synchroscopes, it is suggested that a one-point calibration check be made at frequent intervals. This check may be made by connecting both the incoming and running machine circuits of the instrument to the same source. Under these conditions, the

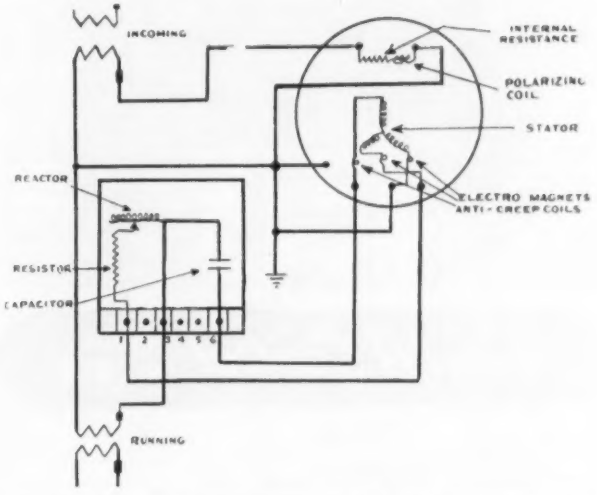


Fig. 17. Internal and external connections of a circular-scale synchroscope.

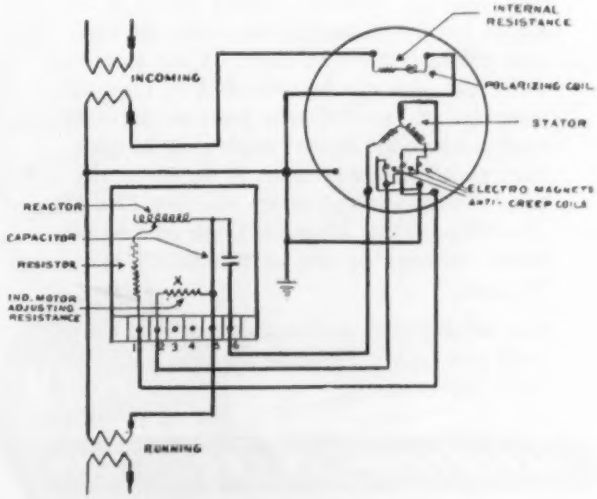


Fig. 18. Internal and external connections of a circular-scale synchroscope with anti-creep adjustment.

New

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pointer will assume the position of synchronism unless the calibration has changed. If changed, the pointer should be reset as outlined under Inspection and Test.

Uneven rotation of the pointer indicates an unbalance in the divided circuit through the reactor. This condition should be corrected by equalizing the currents through each branch as outlined under Inspection and Test.

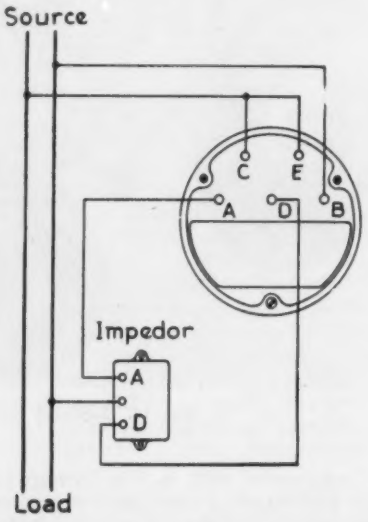

Fig. 19. External connections of AB-12 synchroscope with external impedor for checking pointer location.

If either the polarizing coil circuit or the stator circuit is open, the pointer will have a tendancy to move weakly to an indefinite point. If only one side of the reactor circuit is open, the indication will be as follows when connected for bucking:

An open in the capacitive branch of the split circuit will cause the pointer to indicate approximately thirty degrees to the left (slow) of the point of synchronism.

An open in the inductive branch will result in a shift of the pointer to approximately thirty degrees to the right (fast) of the synchronous point.

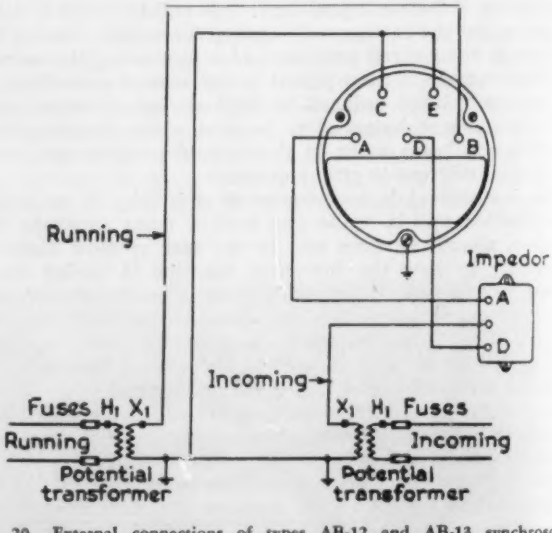

Fig. 20. External connections of types AB-12 and AB-13 synchroscope with potential transformers and external impedor.

A shorted capacitor in the divided circuit will cause the pointer to indicate about ten degrees to the fast side of the point of synchronism when the meter circuits are both connected to the same source. If the inductive reactor is shorted, the pointer will indicate approximately ten degrees to the slow side of the synchronous point. In both the above cases, the condition will be readily noted by the pointer coming to rest with a decided snap.

If, after connecting the synchroscope to the circuits to be paralleled, the pointer rotates in reverse as regards the markings on the dial, there are two conditions to check. First, be sure the connections are correct as shown in Fig. 17—that is, the polarizing coil circuit to the incoming machine and the stator circuit to running machine. If these connections are correct, the connections from the instrument to terminals one and six of the impedor should be interchanged either at the instrument or at the impedor.

(END OF SERIAL)

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Richard Rimbach, Publisher.

Sworn to and subscribed before me this 20th day of September, 1948.

[SEAL]

Abigal J. McVeigh, Notary Public

(My commission expires at the end of the next session of the Senate.)

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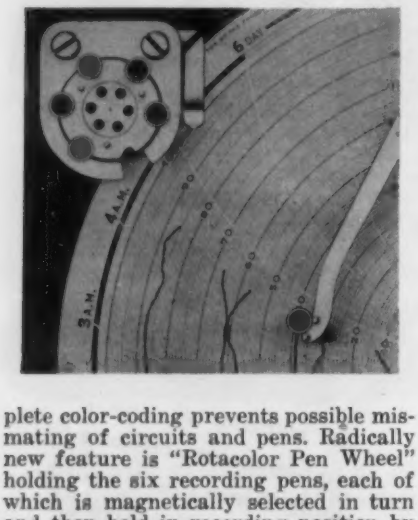
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 1063

Multi-point Single-pen Recorder

New "Multi-record Dynalog Electronic Recorder" is a high-speed instrument, completely electronic in principle, making from one to six different records on one circular chart. Records are colored dots so closely spaced as to make virtually continuous lines. Recorder has only one measuring system (either resistance or emf. type) and a positive-acting switching unit automatically brings vari-colored pens into recording position at 6-second intervals, in any sequence desired. Sequence and number of points may be changed easily. Com-

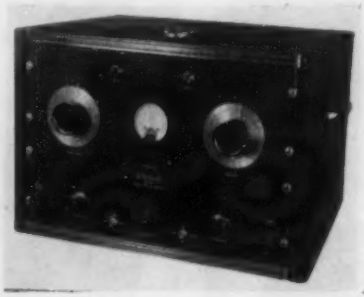


plete color-coding prevents possible mismating of circuits and pens. Radically new feature is "Rotacolor Pen Wheel" holding the six recording pens, each of which is magnetically selected in turn and then held in recording position by single pen arm. Except for this feature, new recorder is like maker's other "Dynalog" (electronic) instruments in design and construction and, like these, may be used for measurement of temperature, pressure, humidity, liquid level, pH, conductivity, speed, and other process variables. A "dry ink" insures clean recording and makes possible continuous operation for several weeks without re-inking. — *The Foxboro Co., Foxboro, Mass.*

Please mention number **1101** when filling out card

Automatic-control Analog

New "Servoscope" test instrument provides continuous performance data of servomechanisms or process controls. Frequency response can be plotted in a few minutes and transient characteristics deduced. A carrier (50 to 800 cps.) modulated test signal (¼ to 16 cps.) supplied by "Servoscope" may be routed through mechanism being designed or under test. Rapid measurements may also be made of frequency versus amplitude attenuation and phase shift. Corrective networks and adjustments may be introduced without resorting to costly experimental revisions in system.

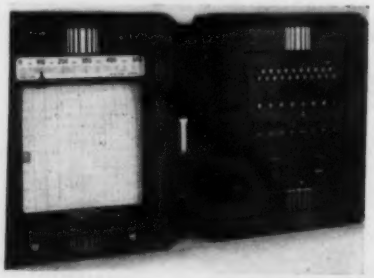


Tedious mathematical design analysis is largely eliminated. Transfer functions are easily derived. Visual display of signal amplitude and phase on a scope screen gives quick comparative values. Instrument may be used to check complete servo loops or any of their components, such as motors, synchros, gyros, amplifiers, accelerometers, etc. "Servoscope" provides test signal carrier from 50 cps. to 800 cps. at 115 volts; amplitude range from 0 to 20 volts rms; phase lead or lag accuracy to within 2° (phase dial is calibrated from 0° to 360° in 1° divisions); power consumption is 40 watts.—*Servo Corp. of America, New Hyde Park, N. Y.*

Please mention number **1102** when filling out card

160-point Rapid Indicator and Recorder

New "Speedomax" rapid recording equipment consists of two parts, a recorder and a switch assembly — both



housed in separate cases. It automatically logs as many as 160 separate thermocouple temperatures in succession at a rate of four seconds per point. In case of trouble, operator can cut thermocouples out of measuring sequence in banks of 20 at a time, until instrument is concentrated on particular group of temperatures in which he is interested at the moment. Or, he can set instrument to record any single thermocouple, or to record all points continuously. In usual operation, instrument simply indicates while numbered lights identify each couple. Should any temperature reach a preset limit, "Speedomax" automatically starts its recording chart drive, begins to record all points as a series of numbered dots, and operates an alarm. — *Leeds & Northrup Co., 4934 Stenton Avenue, Philadelphia 44, Pa.*

Please mention number **1103** when filling out card

Tearing-strength Tester

New "Elmendorf Junior Tearing Tester" primarily developed for paper and paper products, is also used on textiles, metal foils, plastic films and other sheet materials. Tester has capacity one eighth that of maker's standard instrument; total capacity is 200 grams, and

it is available in four calibrations, direct reading in grams when testing either 1, 2, 4, or 8 sheets. A carefully calibrated pendulum provides driving force to tear sample held between two pairs of jaws.—*Thwing-Albert Instrument Co., Penn St. at Pulaski Ave., Philadelphia 44, Pa.*

Please mention number **1104** when filling out card

Portable Oven-temperature Tester

New "Type DO-50" portable oven-temperature tester for checking performance and efficiency of heating appliances is sensitive d-c, millivoltmeter calibrated for use with iron Copnic (Constantan) thermocouples having re-

sistance of 2.0 ohms. Tester consists of 3½" panel instrument mounted in small leatherette-covered case with compartment for storing thermocouple assembly and leads. Scale range is 0 to 650°F; accuracy is ±5% of full-scale value. —*Meter and Instrument Div., General Electric Co., Schenectary 5, N. Y.*

Please mention number 1105 when filling out card

Dew-point Apparatus

New model of "Alnor Dewpointer" embodies three improvements to provide greater operational dependability

in measuring dew point. (1) Manometer scale has been made longer to increase ease and accuracy of reading; (2) thermopiles now measure temperature inside observation chamber; (3) resistance thermometer tells when temperature of gas sample has stabilized to temperature of fog chamber.—*Illinois Testing Labs., 420 N. LaSalle St., Chicago 10, Ill.*

Please mention number 1106 when filling out card

Rubber-hardness Gage

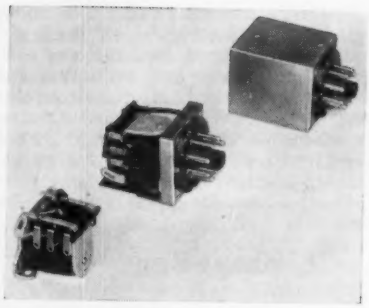
New pocket-size rubber gage measures hardness of rubbers and other elastomers from 15 to 95 shore. Each

unit supplied with test block of known shore hardness. Gage has only one moving part without linkage. Scale can be easily read; no complicated set-up is necessary — merely press gage against sample. — *Clarkstan Corp., 11927 W. Pico Blvd., Los Angeles, Calif.*

Please mention number 1107 when filling out card

Relay for A.c., D.c., Rectified A.c.

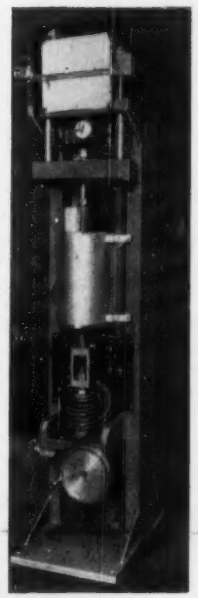
New "Type 118XBX" small-size control relay for d.c., a.c. or half-way rectified a.c., has d-p.-d-t. contacts rated 2 amperes at 115 volts a.c. Normal d-c. operating power is 0.15 watts with maximum coil resistance of 2,200 ohms.



A-c. relays operate on approximately 9 volt-amperes with coils up to 115 volts 60 cycles. Open type relay is 1½" high × 1⅛" long × 1" wide and weighs approx. 2 oz. Unique magnetic structure utilizes two working air-gaps resulting in high sensitivity on d.c. Hinge-pin armature suspension insures reliable operation under severe conditions.—*Struthers-Dunn, Inc., 150 N. 13th St., Philadelphia 7, Pa.*

Please mention number 1108 when filling out card

Creep-testing Machine



New motor-driven screw-type creep testing machine of 20,000-lb. capacity is designed for short-time creep-rupture tests at high temperatures, with minimum of operator attention. Machine automatically maintains constant loads up to 100,000 lbs./in.² on standard 0.505" diameter specimens while temperatures are held constant up to 2200°F. Machine has flat 10" × 10" chart recorder; elongation versus time curve is automatically and accurately drawn on chart, while elongation is also indicated by a revolution counter read directly in thousands of an inch. Constant deflection is maintained in spring block and constant load is applied on specimen during elongation. When specimen ruptures, both motor and clock are stopped. Machine can also be adapted to short-time tensile tests, constant strain-rate tests, or relaxation tests. Machine weighs approximately 1,200 lb., is 7' high, and requires a 16"×30" area.—*Baldwin Locomotive Works, Testing Equipment Dept., Philadelphia 42, Pa.*

Please mention number 1109 when filling out card

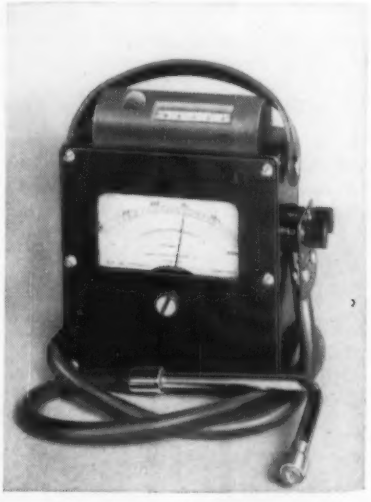
Automatic Weigher

New "M-118-D" automatic weigher is capable of automatically printing and visually indicating dormant loads with rapidity and accuracy. Capacity is from 1,000 to 100,000 lbs.—*Streeter-Amet Co., 4101 N. Ravenswood Ave., Chicago 13, Ill.*

Please mention number 1110 when filling out card

Low-range Pyrometers

New "Type 500" pyrometer is a portable low-range surface temperature measuring instrument in which a new high-sensitivity movement makes possible low range of only 0 to 150°F. Instrument is equipped with manual cold-end adjuster, operated by holding thermocouple against aluminum test block and turning cold-end adjuster screw until pyrometer reading duplicates indications of thermometer. For use in checking surface temperatures of panels



in heating and cooling installations, also for other surface temperature applications in this low range.—*Illinois Testing Labs., Inc., 420 N. La Salle St., Chicago 10, Ill.*

Please mention number 1111 when filling out card

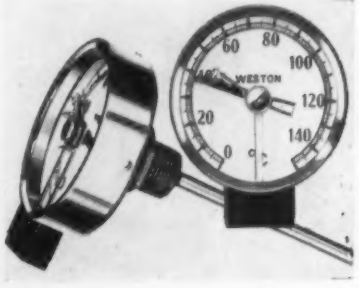
Industrial Thyratron Tube

New "Type GL-5544" thyratron tube for industrial applications has design features such that tube requires no snubber circuit for most motor control applications. Specifications include: filament voltage, 2.5 volts; filament current, 12 amps; peak anode voltage, forward and inverse, 1500 volts; peak cathode current, 40 amps; average cathode current, 3.2 amps; current averaging time, 15 seconds; ambient temperature range −55 to +70°C.—*Tube Divisions, General Electric Co., Schenectady, N. Y.*

Please mention number 1112 when filling out card

Contact-making Thermometer

New contact-making thermometer consists of maker's all-metal thermometer with an adjustable contact arm. A screw-type terminal block mounted on periphery of case front provides for an



easy electrical connection. Contacts are of magnetic type which assure positive action during make and break. Contact arm is easily set to make contact at any temperature over the entire scale and, although contact can be broken manually after an alarm has been sounded, contacts break automatically on a temperature change of about 5%. Instrument can be supplied to make contact on either increasing or decreasing temperature. Accuracy as an indicating thermometer is ±1%; and as a control device ±1½% of full-scale range. Available in stem length from 2½" to 24", longer stems on special order.—*Weston Electrical Instrument Corp., 617 Frelinghuysen Ave., Newark 5, N. J.*

Please mention number 1113 when filling out card

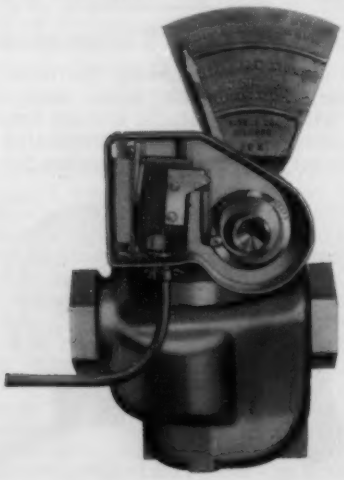
Fluxmeter Calibrating Unit

A new device for calibrating maker's indicating fluxmeter and fluxmeter-type photoelectric recorder consists of "Alnico" magnet rod and housing with built-in search coil which is tapped and connected through selector switch and terminal post. Magnet is approximately 10" long and ⅝" in diameter. To use, unpainted end of magnet is placed in opening atop housing. Unit then is connected in series with search coil to be used in making flux measurement, and switch is set at desired value of flux-linkages. When magnet is removed from housing, desired flux-linkage takes place. This makes it possible to calibrate fluxmeter or recorder so that each millimeter of scale reading will be equivalent to known value of flux-linkages.—*Meter and Instrument Div., General Electric Co., Schnectady 5, N. Y.*

Please mention number 1114 when filling out card

Flow Indicator Alarm System

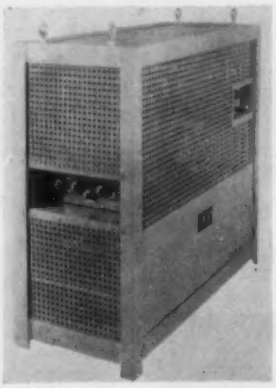
New automatic electric alarm system for maker's flow indicators sets off light or sound signal when high or low limits of flow are reached. System consists of selectivity controls, sensitive microswitch and electric wires leading to alarm. Pointers of controls are set at desired maximum and minimum rates of flow and locked. Microswitch closes contact and sets off alarm. Alarm may be set to operate when rate of flow exceeds limits of a fraction of a gal. per min.—*Henszey Co., Watertown, Wisc.*



Please mention number 1115 when filling out card

Voltage Regulators

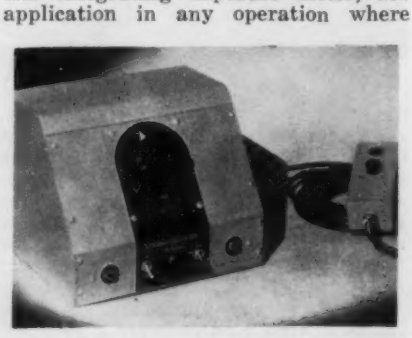
Two new voltage regulators of 5- and 10-kva capacities, contain all design changes that are features of lower-capacity units; are available in either 115-volt or 230-volt models. Incoming line voltage may vary between 95 and 125 volts or 190 and 250 volts a.c. without affecting regulation accuracy of 0.5%. Simultaneous load change from 10% to 100% of rating will not affect regulation accuracy. Harmonic distortion never exceeds 5% in standard models and 3% in "S" models. Line frequency changes between 50 and 60 cycles do not affect the output voltage or performance.—*Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn.*



Please mention number 1116 when filling out card

Exposure Meter

New "Totalux" automatic photoelectric integrating exposure meter, for application in any operation where photographic exposures must be held within close limits between 3 seconds and 60 minutes, automatically terminates exposure after predetermined number of "counts" or foot candle seconds have been given copy board or printing frame. Operates at illumination levels between 50 and 400 foot candles. Consists of exposure integrator and totalizer, connected by 20' rubber-covered cable. Operates on 115 volts, 50-60 cycle a-c. circuit.—*General Electric Co., Schenectady 5, N. Y.*



Please mention number 1117 when filling out card

Low-energy Detectors

New end window ion counter features high efficiency in detection of low energy beta radiation.—*Instrument Div., Kelley-Koett Manufacturing Co., Covington, Ky.*

Please mention number 1118 when filling out card

Pressure Pick-ups

Three new "SR-4 Fluid Pressure Cells," extending available ranges down to 0 to 200 lbs./in.^{2} (one-tenth of previous minimum range) have calibration accuracy at any pressure within ±0.25% of full range. Other new ranges are 0 to 500 and 0 to 1000 lbs./in.^{2}. Devices can be used in any gas or liquid pressure system by screwing into a tapped hole opening into system, giving fluid access only to a sealed tube in cell. "SR-4" resistance wire strain gages, bonded to outside wall of this tube, convert elastic deformation into change in electrical resistance. This change of resistance may be measured by an indicator or recorder at considerable distance, or it may be used to trip a relay or actuate a control device.—*The Baldwin Locomotive Works, Philadelphia, 42, Pa.*

Please mention number 1119 when filling out card

Insulation Tester

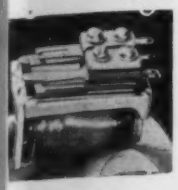
New "Minor Megohmer" (insulation tester) is characterized by light weight (3 lbs.), small size (5⅜" × 3¾" × 3½") and easy portability. It is of the hand-crank type, having a d-c. generator with 500-volt output. Measuring system is of true ohmeter cross-coil

type, which gives dead-beat direct readings independently of generator speed. Scale is clear and legible; range 0-50 megohms and infinity. Instrument comes in molded Bakelite case of burr walnut appearance, with solid leather carrying case, set of six-foot test leads and fifty megographs for recording insulation resistance measurements.—*Herman H. Sticht Co., Inc., 27 Park Place, New York City.*

Please mention number 1120 when filling out card

Miniature Relay

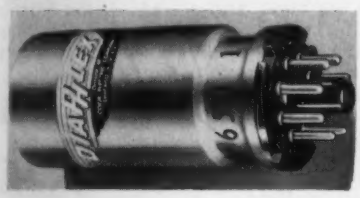
New "Series MTA" telephone type relays for a-c. operation up to 220 volts, 60 cycles, weigh 1¼ oz. and measure 1½" × 1-7/32" × 11/16". Fitted with twin palladium contacts (2 amperes non-inductive load) and available in single or double spring stack with any contact combination up to 12 springs. Dissipation only 0.50 to 0.75 watts; operates within 18% of rated voltage without hum.—*Potter & Brumfield Sales Co., 549 W. Washington St., Chicago 6, Ill.*



Please mention number 1121 when filling out card

Time-delay Switch

New "Tarrytron" time-delay unit with settings available from one sec. to two min. duration is stable in operation when subjected to as high as 12 G's acceleration; heater currents can be ranged from 6 volts to 115 volts, a.c. or d.c.; size of unit is only 2-11/16" long by 1¼" in dia., and total wt. only 3 oz. Furnished with octal plug-in base. Timing tolerances vary from 3-10% over range of 1-120 secs. intervals.—*Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.*



Please mention number 1122 when filling out card

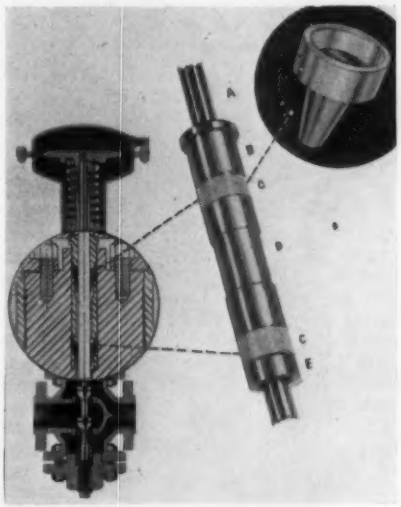
Phase-sequence Indicator

New phase-sequence indicator is entirely static, with no moving parts, bearings, or pivots. Applicable to 120-, 240-, or 480-volt circuits at 25, 50, and 60 cycles. It is housed in a leatherette-covered wooden case, with a cover to protect two "Type NE-51" standard neon lamps. Three 30" leads, integral parts of instrument, have insulated clips to assure quick, easy operation. Indicator can be used: 1. To predict directional rotation of polyphase meters. 2. To determine proper connections for paralleling generators, transformer banks, and power buses. 3. To determine proper connections for watt-hour meters, reactive-component meters, kva meters, reverse-power relays, and phase-sequence relays. 4. To check vacuum-tube, thyratron, rectifier, and inverter installations. 5. To study vector relations of polyphase circuits.—*Meter and Instrument Div., General Electric Co., Schenectady 5, N. Y.*

Please mention number 1123 when filling out card

Valve-stem Seal

New "Dahl-Seal" is said to provide for the first time a frictionless, leak-proof valve stem, regardless of static pressure on valve body. Valve stem is hermetically sealed by force of system pressure due to special shape. It eliminates and replaces conventional packing box. No take-up or adjustment is necessary as it is inherently lubricated and is completely resistant to chemical attack. Valve stem can be positioned to accuracy of 0.001" at full vacuum, atmospheric to 25,000 gage. "Dahl-Seal" is said to open an entirely new field of instrumentation. — *Hammel-Dahl Co., 243 Richmond St., Providence 3, R. I.*



Please mention number 1124 when filling out card

Flame-failure Safeguards

New "Fireye Systems FF-2 and FF-6" are said to meet the need for efficient flame failure safeguards and controls on gas-oil conversion burners. System "FF-2" is used on oil burners which employ gas as an alternate fuel. The system consists of photoelectric scanner, flame rod and programming control. Photoelectric scanner monitors main oil flame providing instantaneous safety shutdown on flame failure. Control programs sequences of ignition and fuel systems, and rod monitors pilot gas flame, preventing main fuel valve from opening until pilot flame is properly established. When system is converted to gas, rod monitors continuous gas pilot flame and control programs fuel and ignition systems. System "FF-6" is similarly used on gas burners which use light oil as an alternate fuel.—*Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*

Please mention number 1125 when filling out card

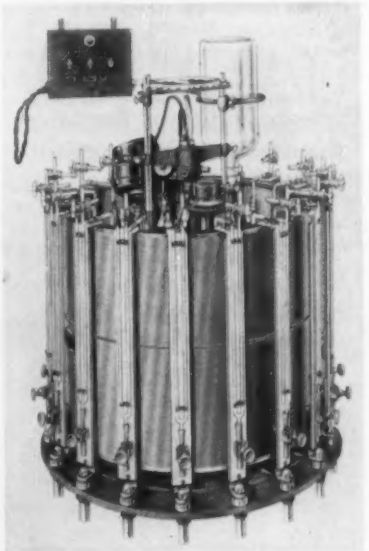
Solenoid-operated Valve

New 4-way solenoid valve is of balanced spool type, controlled by a built-in solenoid. Manifold design permits flexibility in piping arrangement; lines may be connected to bottom, sides or a combination of both. Three point mounting pads are provided to prevent distortion of parts. Adaptable to straight line piping, with valve capacity equal to rated pipe size. Solenoids and spool and sleeve assembly may easily be replaced. Other features: only 5/32" solenoid stroke, silent mechanical operation, low current consumption, valve proper made of corrosion resistant materials, and time required for pushbutton response only 1/20 second.—*Hanna Engineering Corp., Chicago, Ill.*

Please mention number 1126 when filling out card

Manometer-vibrating Apparatus

New "Aminco-Lardy Rotary Warburg Apparatus" features pivotal shaking action which makes it possible for manometers to be read more easily and accurately (while in motion). Manometer legs move radially, in a horizontal plane, about an axis centered between them. Lateral movement of manometer is only ¼ mm. at max. flask travel, ten times that of manometer legs. Apparatus accommodates

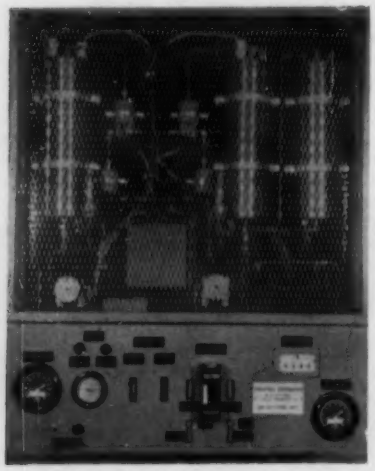


various types of manometers, and has three speeds of oscillation (70, 112, or 180 per min.). Amplitude of oscillation may be changed from 1 to 4 cm.—*American Instrument Co., Inc., 8010-8020 Georgia Ave., Silver Spring, Md.*

Please mention number 1127 when filling out card

Air Dehydrator

New "Dry Air Purging Unit" is self-contained and automatic; provides a continuous source of dry high-pressure

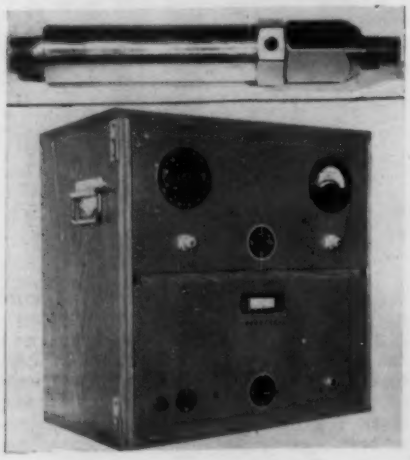


air. Maker states that it "will replace inert gas or nitrogen bottle purge systems heretofore used." Unit consists of desiccant chambers automatically regenerated without interrupting purge air supply. Features are: purge air-flow indicators, reducing regulators to provide proper pressure for each service, a totalizing air-flow meter, and safety devices to prevent use of damp air for purging. Unit can be provided complete with air compressor or, if a compressed air supply is already available, dryer section alone can be furnished. Unit operates on a 110-volt a.c. or d.c.—*Industrol Corp., 88-35 76th Ave., Glendale, Brooklyn 27, N. Y.*

Please mention number 1128 when filling out card

Pressure Indicator for Microsecond Pressure Transients

New "Model E Pressure Indicator" uses a capacitor type pick-up. Depending on free diameter and thickness of the diaphragms, natural frequencies

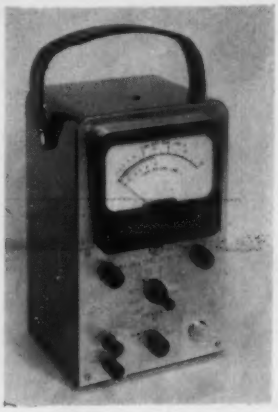


can be chosen at random, highest limit 1.2 Mc. Pressures from vacuum up to 60,000 lbs./in.^{2} can be registered by interchanging diaphragms. A frequency-modulated carrier is applied securing linear frequency response from 0 to 1.5 Mc. Instrument offers freedom from practically all external electrical and mechanical interference. Accuracies of 0.25% can be achieved by applying a newly introduced dynamic calibration which calibrates entire system during the test. Pick-up is linked to oscillator by a coaxial cable, permitting a length up to 200 ft. Any standard cathode-ray oscillograph can be adapted for visualizing indicated pressure phenomena.—*Rutishauser Scientific Instruments, Box 37, Altadena, Calif.*

Please mention number 1129 when filling out card

Tone Generator

New "Type WA-26A" portable tone generator, designed primarily for use in broadcasting studios, combines high-



quality audio oscillator and sensitive indicator to supply suitable tone for use in equalizing remote telephone lines. Tone-generator circuit is R-C type, allowing selection of 10 frequencies from 50 to 15,000 cps. Output is metered and calibrated in dbm. Output of either 150 ohms or 600 ohms may be selected. Supplied with black leatherette carrying case. Weight with batteries is 9 lbs., 4 ounces.—*Radio Corp. of America, RCA Victor Div., Camden, N. J.*

Please mention number 1130 when filling out card

Tachometer Head for Aircraft Pad Mounting

New "Type 55" tachometer head for AN specification pad type aircraft mountings is for use with maker's

indicators. Weighs only 11 oz., and requires very small operating torque, and permits full-scale indicator ranges as low as 200 rpm. or as high as 10,000 rpm. Connections are made with standard AN fittings; overall projection from mounting surface is only 1⅛".—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Please mention number 1131 when filling out card

Electrophoresis Apparatus

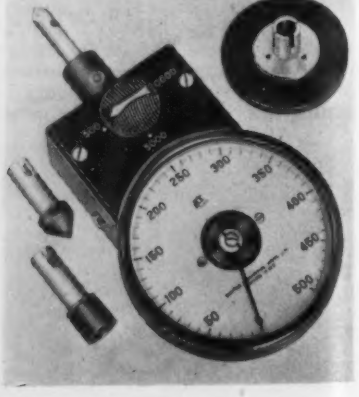
New "Aminco-Stern Electrophoresis Apparatus," measuring only 38" × 30" × 66" high, is said to be of great value

for making electrophoretic, diffusion, adsorption and refractive index measurements. Apparatus detects concentrations of 0.002% and measures concentrations of 0.01% and 2.5% simultaneously. Two samples can be analyzed at one time, and a total of six samples can be analyzed in nine hours. Included are rapid dialysis facilities, a chamber for freezing and storing samples, a sealed mechanical refrigeration system, precision Schlieren optics, complete built-in photographic facilities, and a triple slit, bar, straight-edge unit.—*American Instrument Co., Inc., Silver Spring, Md.*

Please mention number 1132 when filling out card

Hand Tachometer

New "Model ATH4" hand tachometer effects transmission of driving spindle rotation to indicating pointer in first stage mechanically and in second stage magnetically. Speed changes are indicated instantaneously. Pointer always reads in same direction irrespective of direction of rotation of spindle. Pointer shaft is carried between two jewel bearings. A push-button device enables op-



erator to arrest pointer at indicated reading. By pushing button on opposite side of instrument, pointer returns to zero. Each model has three ranges. Required range is selected by turning arrow on knurled knob to range clearly marked on instrument. "Model ATH4" has maximum range of 0 to 50,000 rpm. or 0 to 25,000 rpm. Instrument accuracy is guaranteed to within ±0.5% over wide range of ambient temperature variation. — *Equipoise Controls, Inc., 100 Stevens Ave., Mount Vernon, N. Y.*

Please mention number 1133 when filling out card

Power Analyzer

New power analyzers permit complete electrical tests for a-c. power measurement—3-phase, 2-phase, single-

phase; volts, amperes, kw.(hp.), rkva. (pf.) phase rotation indicator. Illustration shows one of several models available. Circuits nominally 120/240/480/575 volts; current ranges min. full scale, 1.5 amperes to max. 300 amperes in nicely overlapping steps 1.5/5/15/50/150/300; kilowatts, polyphase, full scale 300 watts to 240 kw.—*Niagara Electrical Instrument Co., 559 Ellicott St., Buffalo 3, N. Y.*

Please mention number 1134 when filling out card

Portable Amplifier

New "Type BN-2A" portable remote amplifier provides high-fidelity audio pickup for AM and FM broadcast programs and features excellent frequency response, low noise level and low distortion. Amplifier has built-in power supply for 115-volt, 60-cycle outlets, and facilities for battery operation. Each channel offers overall gain of 92.5 db. High-level mixing is used throughout. Amplifier has capacity for four microphone inputs. Amplifier is 14½"

long; weighs 29 lbs.—*Radio Corp. of America, RCA Victor Div., Camden, N. J.*

Please mention number 1135 when filling out card

Thread Staging Fixture

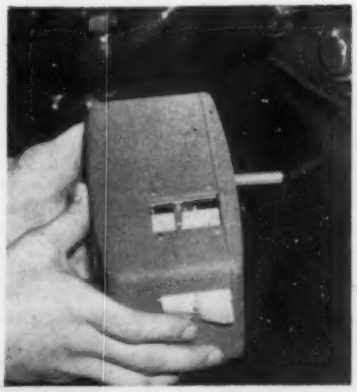
New "See-All" thread staging fixture is for inspection by optical projection of screw threads ranging in diameter

from 0.073" to 1.000". It is said to provide practicable, fast methods of loading and holding screw threads, in gaging major and minor diameters, crest, flank angle, worn tool allowance and lead. The fixture provides simple helix angle adjustment for use on optical comparators in which no work stage with helix adjustment is provided. Two sets of adjustable vee assemblies are supplied with each fixture; one for sizes 0.073 to 0.216 O. D. and the other for sizes from 0.250 to 1.000 O. D. A set of 25 setting masters is supplied with new fixture for alignment with coördinated thread charts on comparator. Tapered threads in sizes 1/16-27 to 3/4-14 can be inspected.—*Engineers Specialties Div., 980 Ellicott St., Buffalo 8, N. Y.*

Please mention number 1136 when filling out card

Recording Vibrometer

New recording vibrometer measures and records frequency, displacement, and wave shape of mechanical vibra-

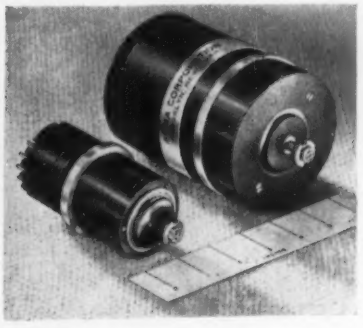


tion. Built to operate either when mounted or held in hands, vibrometer weighs only 7 lbs. and is less than 8" in length. Useful for testing reciprocating and rotating machinery within vibration frequency range of 10 to 120 cycles per second. Records both steady-state and transient vibrations. A prod extending from one side is set in motion when held against a vibrating body. Motion is amplified and transmitted to stylus which inklessly records vibration on wax paper. Another stylus produces timing mark near edge of wax paper every one-third of a second. Synchronous motor operates from 115-volt, 60 cycle power supply. Two push buttons give chart speeds of 1" per second and 3" per second. Motion of stylus can be observed through a window in top of all-aluminum case. — *General Electric Co., Schenectady 5, N. Y.*

Please mention number 1137 when filling out card

Trig.-function Resolvers

New line of electrical resolvers is designed specifically for electromechanical computing and control equipment.



Developed primarily as parts of Navy instruments, they are accurate and dependable means of solving problems involving trigonometric functions. Each is designed to deliver two alternating voltages proportional respectively to $e_1 \sin A + e_2 \cos A$ and $e_1 \cos A + e_2 \sin A$, where e_1 and e_2 are voltages applied to two primaries and A is angle through which rotor has been turned from position defined as electrical zero.—*Arma Corp., 254 36th St., Brooklyn 32, N. Y.*

Please mention number 1138 when filling out card

Industrial Raman Spectroscopy Equipment

Complete Raman equipment designed for industrial laboratories includes a high-speed Raman spectrograph and powerful Raman excitation equipment. Typical compounds give useful spectrograms with exposure times of about one minute. For example, in 45-second exposure, a 4½-ml. iso-octane sample yields over 15 usable-density Raman

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GALVANOMETERS

Available with natural frequencies from 15 c.p.s. to 1500 c.p.s., electromagnetically damped and to sensitivities as high as 2" per microampere at 1 meter focal distance.

CENTURY TUBULAR TYPE GALVANOMETERS

The Model G-14 in hard chrome plated brass tube and the Model 205 of heat-treated, non-magnetic stainless steel. Rugged and durable, yet possesses extreme sensitivity. Internal suspensions are manufactured by a patented process which provides unequaled balance. Hermetically sealed giving maximum efficiency under all climatic conditions.

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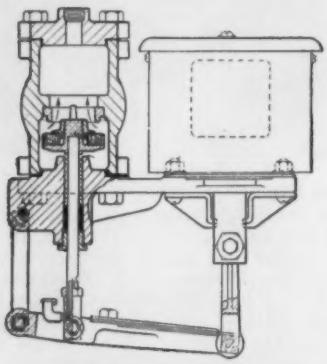
lines on Tri-X Pan film. Special low-pressure high-current mercury lamps excite well-defined Raman lines, and spectrograph has excellent definition over whole 4000-6500-A range. Dispersion provided is said to be exceptional for an *f*/3 camera, permitting use of fast films without loss of resolution. In addition, coated optics, well-designed baffles, and low-pressure lamps minimize background so that even weaker Raman lines are detected.—*Lane-Wells Co., Pasadena, Calif.*

Please mention number 1139 when filling out card

Solenoid Valve for Emergency Service

New "Series No. 6000" 150-lb. globe type solenoid valve, designed to meet emergency or safety requirements, is



intended for service in which valve is normally open; is capable of remaining closed for indefinite periods of time, and valve will remain closed as long as a pressure above three lbs. exists on the inlet side. To permit easy opening of valve once emergency has passed, a simple piping arrangement is utilized. Valve has heavy cast body, suitable for pressures up to 150 lbs., to handle steam, hot or cold water, gas, air, gasoline or oil. Available in sizes from ¾" to 2½". May be used on 110, 220, 440 volt, 60 cycle a.c., and is provided with ⅛" I.P.T., opening cap.—*Johnson Corp., Three Rivers, Mich.*

Please mention number 1140 when filling out card

Standing-wave-voltage Ratio Amplifier

New "TAA-16" amplifier, useful in determining standing wave voltage ratio when used in connection with square law detector probes and slotted waveguides, has two inputs, selectable by switch for rapid comparison. Operating frequencies are from 500 to 5000 cycles and operation can be wide band or highly selective. Selective network is panel tuned. Output meter is calibrated directly in standing wave voltage ratio.

External meter may be used if desired. Full scale meter readings are obtained with 15 microvolts at the input under wide band operation, while 10 microvolts signal will produce this result under selective operation. Power supply is electronically regulated for good stability. Good shielding permits full gain to be used without disturbance from noise or 60 cycle harmonics. "TAA-16" amplifier is supplied in cabinet and is suitable for rack mounting. Dimensions: height 9", width 20", depth 12". Weight: 30½ lbs.—*Browning Labs., Inc., Winchester, Mass.*

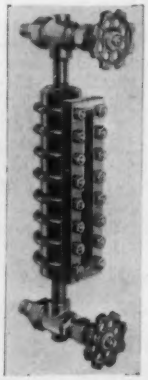
Please mention number 1141 when filling out card

Deposited Carbon Resistors

New "Deposited Carbon Resistors" "DCF" for applications up to 1 watt, and "DCH" for applications up to 2 watt, provide extremely high stability and low voltage coefficient, and assure low capacitive and inductive impedance. Available in 3 tolerances: 1%, 2% and 5%. Voltage coefficient on a statistical average is approx. 10 ppm. per volt. Resistance ranges are: Type DCF—200 ohms to 5 megohms, Type DCH—500 ohms to 20 megohms.—*International Resistance Co., 401 N. Broad St., Philadelphia, Pa.*

Please mention number 1142 when filling out card

Liquid-level Gage



New large-chamber liquid-level gage is claimed to give "an accuracy of level reading never before possible" for use in gaging liquids that boil, where liquid fluctuates rapidly in the glass. Gage chamber is of large diameter so that effect of boiling action and fluctuations on liquid level is minimized. Gage is indicated for use on light-end services, also as a visual standpipe. It is of the flat-glass, reflex type, and is made in sections up to any desired length, in multiples of maker's standard "No. 7 Reflex Glasses."—*Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45 Mass.*

Please mention number 1143 when filling out card

60-mm. Spotting Scope

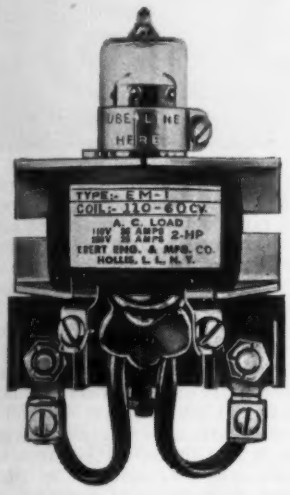
New 60-mm. spotting scope, providing greater visual performance and eye-relief, has coated optical system that provides maximum light-gathering

power and features coarse and fine adjustment focusing devices. Under 14" in length, the scope has caps that screw on eyepiece and objective to make it dust proof.—*Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.*

Please mention number 1144 when filling out card

Mercury Relay

New relay incorporates free floating magnetic plunger which is said to (1) insure smooth, silent operation,

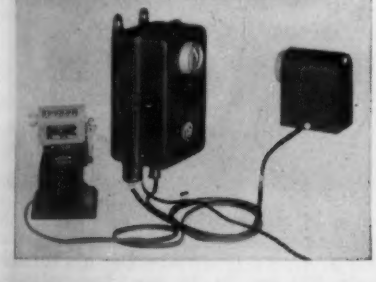


(2) reduce size of glass enclosure and (3) insure flicker-proof performance in sign flashing applications. Heavy tungsten contacts with mercury-to-mercury make-and-break are hermetically sealed for dust-and moisture-proof operation. There is no exposed arc; relay is safe under all operating conditions. Coil and load terminals are readily accessible. Operates on ½ wave unfiltered current. Height, 4"; width, 2⅝"; depth, 2¼". Available in 2 and 3 pole units.—*Ebert Engineering & Mfg. Co., 185-09 Jamaica Ave., Hollis, Long Island, N. Y.*

Please mention number 1145 when filling out card

Photoelectric Counter

New "Type 20AP5" photoelectric counter is for installation on any conveyor system or automatic machine.



Light source has an adjustable lens system which permits narrowing down the light beam for counting very small objects. Packaged complete including light source, photoelectric control, and electric counter. Plugs into 115-volt 60-cycle a.c. Speed of operation: up to 600 cpm. Operating range: 6 ft. between photoelectric unit and light source.—*Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Please mention number 1146 when filling out card

Illuminator Magnifier

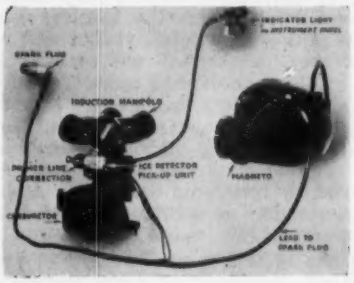
New magnifier-illuminator combines in one unit means for lighting and magnifying objects for visual inspec-

tion or fine work in laboratories. Viewing head contains light source (three six-watt, 9" fluorescent tubes) and a 5" lens which brings objects into sharp focus at 13". Triangle-shaped lens and lamp housing may be suspended above work in any desired position at the touch of a hand; and whole assembly can be quickly clamped to edge of bench, desk or table.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.*

Please mention number 1147 when filling out card

Aircraft Ice Detector

New carburetor ice detector for aircraft flashes neon signal light in cockpit to indicate condition of throttle or



fuel icing, warning pilot to turn on preheater. Energy from spark plug lead is fed to transformer and balanced-bridge circuit containing "neutralizing" condenser and ice-pickup probe. Ice unbalances circuit, flashing signal.—*Lindberg Instrument Co., 830 Folger Ave., Berkeley 2, Calif.*

Please mention number 1148 when filling out card

Reset Counters

New "Y Productimeter" reset stroke and rotary counters are available in reset and non-reset styles, in 3, 4, 5, and 6

WHY BUY 3 UNITS when 1 TWIN SEAL UNIT WILL SERVE 3 WAYS

10,000 psi—no leakage or seepage

1 PORTABLE PRESSURE TESTING
Weight, filled with oil, 8½ lbs.

2 BENCH WORK WITH TEST GAGE mounted on aluminum drip pan

3 DEAD WEIGHT TESTING
shown with dead weight attachment mounted on unit.
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For light, delicate operations, where **precision** heat-control is essential—rely on your 4" Weller Soldering Gun. Pliable FLEXITIP slips easily into "ticklish" spots. **Automatic** heat—on in 5 seconds, off when you release trigger—speeds soldering, prevents burning, and enables you to adjust tip temperature to suit job. Perfect balance and handy pistol grip give comfort and control.

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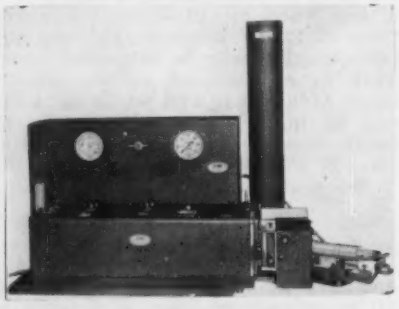
figures capacity. Length of case ranges between 1-1/16" and 2¼"; width is 0.960" and height, 1.238". Figures are black on white, 0.166" high by 0.097" wide; are clear, baked on. Bearings are oil-less automotive type. Stroke style counters have patented ratchet, non-slip pawl drive mechanism. Rotary style has a sleeve clutch mechanism. Shafts are of stainless steel; number wheels have steel running parts. Plexiglas window gives clear visibility and is non-breakable. Operating lever on stroke units is bright plated brass with positive grip. A single turn of knob resets all figures to zero.—*Durant Manufacturing Co., 1914 N. Buffum St., Milwaukee 1, Wis.*

Please mention number 1149 when filling out card

Flame Spectrophotometer

New "Beckman Flame Spectrophotometer" simplifies both qualitative and quantitative analyses of a large number of chemical elements. Its use of a hot flame permits excitation of spectral lines of a large number of elements, including many of the heavy metals and alkaline earths, whereas a cool-



flame instrument excites only those of the alkali metals. Its spectral range covers the ultraviolet, visible and near infrared. Method of use is adaptable to water analyses, metal and ore analyses, determination of inorganic traces and impurities in foods, chemicals, biologicals, pharmaceuticals and in organic materials which can be reduced to inorganic solutions. Samples are atomized and introduced at a uniform rate into a hot oxygen and gas flame through a specially-designed burner. Emission lines are excited and spectrophotometer isolates these lines and measures their intensities relative to a blank or standard. A rate of four analyses per minute is easily maintained. Results are instantly and directly readable on an accurately-calibrated dial. No photographic processes or densitometer comparisons are necessary. Flame temperature and rate of feed of specimen can be held constant "over a long period of time," allowing numerous individual line measurements to be made in succession. Also, flame temperature and feed rate can be exactly reproduced at any time for "check" or "blank" determinations. Analyses can be made on samples as small as 5 cc. Instrument is said to provide sensitivity greater than 0.01 ppm.—an accuracy far exceeding results obtained with filter type instruments. Even traces as small as a few parts per billion can be detected with this instrument.—*Beckman Instruments, Nat'l Technical Lab., S. Pasadena, Calif.*

Please mention number 1150 when filling out card

A-c.-d-c. Power Supply

New "Model 700-SV" combination a-c.-d-c. power-supply unit operates from 115-volt, single-phase, 50-60 cycle

input to provide two independent output circuits. Vernier control on one output circuit enables hair-line settings when checking specific points of instruments being calibrated. Both output circuits are uniformly adjustable from 0 to maximum rating. Circuit No. 1 provides output of 0 to 10 amperes with maximum of 8 volts, or 0 to 30/75/150/300/600/750 volts a.c., with max. of 200 ma. It also provides d-c. output of 0 to 20/50/125/250/500/750 volts with max. of 175 ma. Ripple on d-c. output is less than 0.25%. Circuit No. 2 provides an a-c. output of 0 to 5 amperes with max. of 5 volts, or a-c. output of 0 to 135 volts with max. of 3 amperes, and includes 115-volt constant-potential terminals supplied direct from input circuit.—*Arthur E. Booth Co., 307 E. 3rd St., Los Angeles 13, Calif.*

Please mention number 1151 when filling out card

Video Sweep Generator

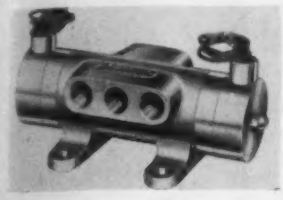
New "Type WA-21A" precision video sweep generator, when used with suitable detector and oscilloscope, facilitates direct viewing of envelope of output wave of a video circuit while input signal sweeps through a range of 100

kc. to 10 mc. at the rate of 60 complete sweeps per second. CW generating section produces sine-wave signals tunable from 100 kc. to 10 mc. for point-to-point or steady rate tests. For special applications, sweep width may be reduced and center frequency adusted to permit detailed observation of response of narrow band-width circuits within the range of 100 kc. to 10 mc. Designed for either bench or rack mounting. Normally furnished in table model 22" wide, 10½" high, 15" deep, weighing 80 lbs.—*RCA Victor Div., Radio Corp. of America, Camden, N. J.*

Please mention number 1152 when filling out card

Solenoid-operated 4-way Control Valve

New model of maker's "CV" control valve series is solenoid operated, compact (over-all dimensions are 7¼" for

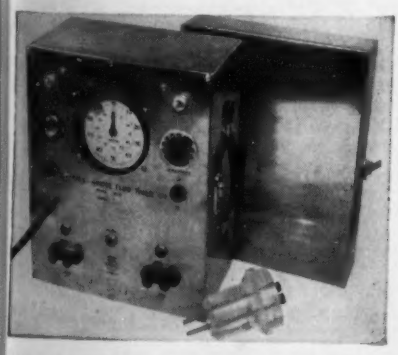


the ⅜" port model, 10⅜" over-all for the ¾" port size), and material subject to contact with operating fluid is noncorrosive. Body is heat-treated, sand cast, aluminum alloy casting; valve piston is solid machined brass sealed with readily replaceable aircraft type "O" ring packings. Designed for operation on maximum line pressures of 150 lbs./in.^{2}, coils are furnished as standard for 110/220 volt current operation with current consumption on 110 volts of 1 ampere. Valve is available with 440-volt coils as standard. Solenoid coils actuate small secondary valve which in turn controls air internally ported from incoming pressure port. Valve piston is thus forced to extreme position at each actuation by injection of positive pressure behind piston. At same time, electrical system is fully protected from contact with operating air. The 5-port 4-way type design permits regulation of either exhaust ports, assuring accurate control of cylinder piston movement. Single solenoid spring return actuation is available. — *Modernair Corp., 4222 Hollis St., Oakland 8, Calif.*

Please mention number 1153 when filling out card

Pasteurizer Flow Timer

New "Solu-Bridge" flow timer checks holding time of short-time high-temperature milk pasteurizers and is based on maker's "Model RT-3." This instrument operates on the conductivity principle; but, unlike its predecessor, is



automatic and can be operated by one person. It incorporates an electric stop-clock graduated in hundredths of a second. Two conductivity cells with ¾" N.P.T. fittings are provided for mounting in flow at ends of holding tube. (An alternative Lucite cell, designed for mounting in standard sanitary fittings as illustrated, is available.) To operate timer, electric stop-clock is set to zero, sensitivity control adjusted to conductivity of flowing water, and an ounce or less of strong salt solution injected upstream of inlet-end cell. As soon as salt front reaches first cell, a-c. Wheatstone bridge unbalances, built-in relay throws, starting clock and switching second cell into circuit. When salt front reaches this cell, clock stops and holding time is read off directly. Duplicate measurements can be made at the rate of one per minute. Extensive tests have shown that agreement among a series of such holding time checks is better than 0.04 second.—*Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J.*

Please mention number 1154 when filling out card

Mechanical Convected Drying Oven

New drying oven has "Limistat" control which shuts off oven completely if temperature rises above control setting.

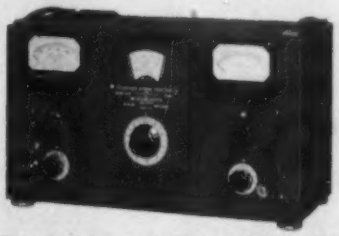
Operates independently of thermostat control and is adjustable for 10° to 100° above setting. Prevents losses due to thermostat failures or unauthorized tampering with thermostat control settings. Available in three sizes from 3 to 18 cubic ft. and two heat ranges of 180 and 260°C. with or without full view window.—*Electric Hotpack Co., Inc., 5029 Cottman Ave., Philadelphia 35, Pa.*

Please mention number 1155 when filling out card

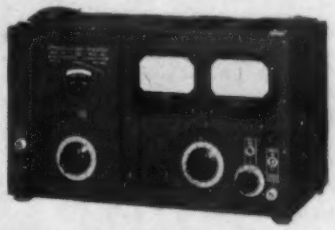
Portable Van de Graaff High-voltage Generator

New "Model L" Van de Graaff generator is said to be a safe, convenient source of high voltage, producing an ap-

Laboratory Standards

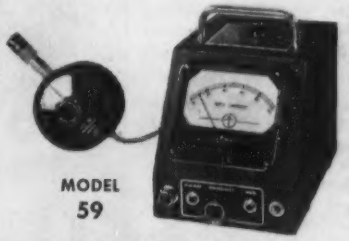


STANDARD SIGNAL GENERATOR
Frequency range: 75 kc. to 30 mc. Output 0.1 microvolt to 2.2 volts.
MODEL 65B



STANDARD SIGNAL GENERATOR
Frequency range: 2 mc. to 400 mc. Output 0.1 microvolt to 0.1 volt.
MODEL 80

SQUARE WAVE GENERATOR
5 to 100,000 cycles. Recommended for AM, FM and television testing.
MODEL 71



MODEL 59
MEGACYCLE METER

MANUFACTURERS OF
Standard Signal Generators
Pulse Generators
FM Signal Generators
Square Wave Generators
Vacuum Tube Voltmeters
UHF Radio Noise & Field Strength Meters
Capacity Bridges
Megohm Meters
Phase Sequence Indicators
Television and FM Test Equipment

A versatile grid-dip oscillator covering the frequency range of 2.2 mc. to 400 mc.

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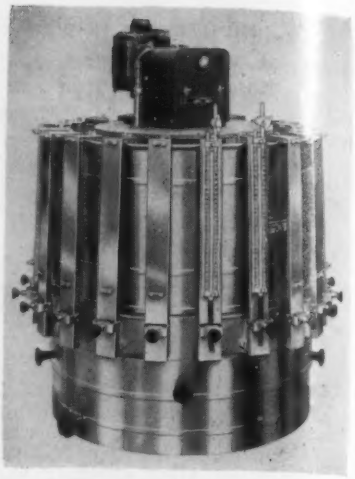
Please mention number 1156 when filling out card

Warburg Analyzer

New "Precision" Warburg apparatus is being utilized in fields such as catalytic oxidations and hydrogenations, glycolysis, vitamin assays, photosynthesis, micro-analysis of gas, fat stability, etc. It provides laboratories engaged in Barcroft-Warburg work with an accurate time- and space-saving apparatus. It allows operator to sit in one position while rotating manometer assembly to bring each manometer into



immediate view without changing position. It accommodates up to 20 Warburg manometers or 10 Summerson differential manometers. Also available in refrigeration model for low temperature work. A 10-unit apparatus is also available.—*E. Machlett & Son, 220 E. 23rd St., New York 10, N. Y.*

Please mention number 1157 when filling out card

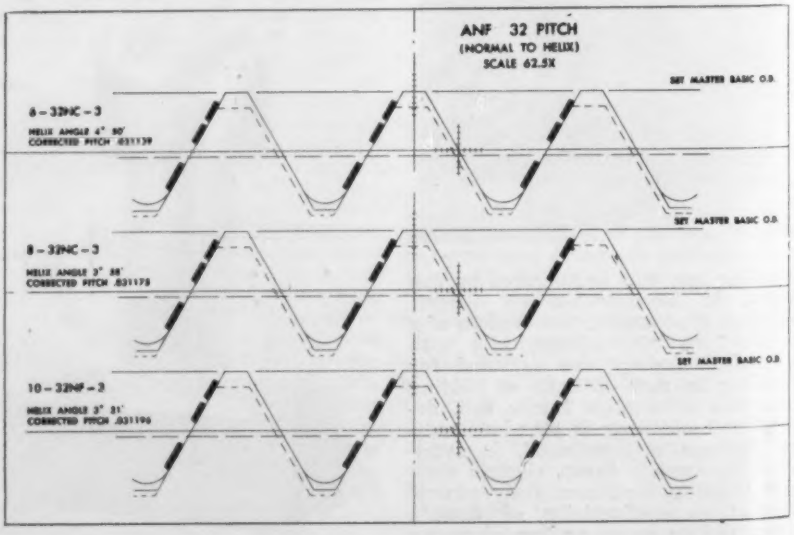
Photoelectric Registration Control

New "Type 23LF3" photoelectric registration control for maintaining accuracy in high-speed printing and cutting operations on paper, cellophane, fabrics, steel, tin, aluminum, or other sheet

Normal-to-helix Thread Charts

New normal-to-helix thread charts aid staging of American National Form threads to correct helix angle. Designed for use with maker's staging fixture, they are also for thread checking wherever threads are held by centers and helix adjustment is taken into account. New screens cover range of standard thread sizes for Class 2 and 3 fit. As these threads are gaged normal to helix, requiring a corrected pitch for requisite helix angle, a separate contour is shown for every thread size. To establish positive alignment of thread shadow with chart contour, one thread flank is shown as a heavy black band and full tolerance on thread thickness is seen on opposite flank of thread contour. A scale in 0.001" increments is provided at pitch line intersection of opposite flank, enabling operator to read any out-of-tolerance measurement. New charts are available at 50× and 62.5× for pitches 12-80, Class 2 and 3. For pitches from 6 to 11 in both class fits the charts are supplied at 31.25×. Available in 6¾" × 9¾" size replacement screens, and 10" × 12" size overscreen style.—*Engineers Specialties Div., 980 Ellicott St., Buffalo 8, N. Y.*

Please mention number 1158 when filling out card

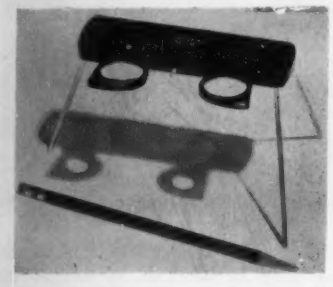


material responds to impulses as short as 0.001 second; and is said to improve product appearance, reduce spoilage, lower production cost, increase production rate. Operates on 115 volts 60 cycle a.c. Output is s-p. d-t. relay, 1000 va.—*Photoswitch Corp., 77 Broadway, Cambridge, Mass.*

Please mention number 1159 when filling out card

Pocket-size Stereoscope

New "Model F-271" folding pocket stereoscope has overall dimensions of 5¼" × 1⅝" × ½", and weighs only 7½ oz. The three legs and lenses may be folded into die-cast body to make an instrument smaller in size than an

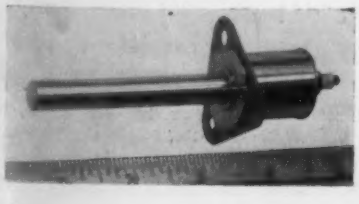


ordinary eyeglass case. Equipped with two meniscus lenses of 4½" focal length and 2½ power magnification. Both lenses may be adjusted horizontally over a range of 50 to 72 millimeters. When set up, the "F-271" is 4" above the photographic prints. — *Fairchild Camera & Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.*

Please mention number 1160 when filling out card

Thermal Switch

New "Airite" thermal switch features: (1) extreme light weight, (2) wide range of temparature adjustment, (3) fast, positive action and (4) long service life. Heart of switch is flexure pivot — frictionless and non-wearing. A high-temperature magnet

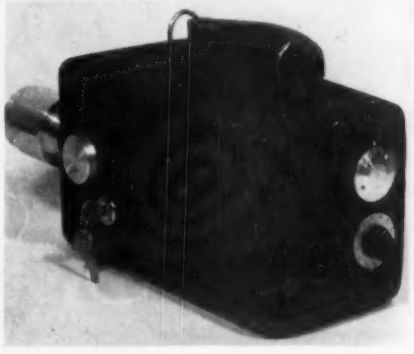


quenches any arcing and compounds its force with that of pivot to provide fast, positive action. Swith has hermetically-sealed, stainless steel housing. Can be changed from normally-open to normally-closed by quick replacement of electrical terminal only. Switch contains no mica, insulated wire or plastic parts and meets new "AS-401, Type III." Designed primarily for fire detection, switch can be used for cycling control of heating and refrigeration systems, handling of oils, chemicals, etc.—*Airite Products Co., 3528 Union Pacific Ave., Los Angeles 23, Calif.*

Please mention number 1161 when filling out card

Oscilloscope Camera

New oscilloscope camera may be used in conjunction with any oscilloscope having a short-persistence screen. Film



movement provides either horizontal or vertical sweep, depending upon orientation of camera. Instrument utilizes 35-mm. film wound on standard 100-foot capacity daylight-loading spools. Speed range is 25 to 850 inches per second on a-c. or d-c. voltages with associated high accelerations and decelerations. Unique ball-bearing-mounted driving and braking mechanism is conducive to low film consumption. Proper focus is achieved by viewing the image on the film itself. A film marker is provided which functions at line frequency or, by means of a switch, may be connected to an external voltage of other frequency. Starting and stopping of camera is effected by a push button at end of an eight-foot cord. A plug is provided for actuation by correlated apparatus if required. Case dimensions 5.75" × 6.25" × 11.0". Weight, complete with cords and plugs, 15.0 lbs.—*Frederick P. Warrick, 8666 Grandville, Detroit 10, Mich.*

Please mention number 1162 when filling out card

Photoelectric Colorimeter

New "Clinical Analyzer" is a photoelectric colorimeter calibrated for 60 clinical determinations. It uses selected test tubes of 17 mm. and 11 mm. diameter; is completely self-contained, operates on 110 volts a.c., and incorporates a built-in voltage regulator. Five optical glass filters mounted in a revolving filter disk permit quick and easy selection of filter desired. 3½" mirror scale combined with a combination tubular and knife edge pointer provides precision readings unaffected by parallax. Both linear and logarithmic scales are incorporated; thus, readings can be

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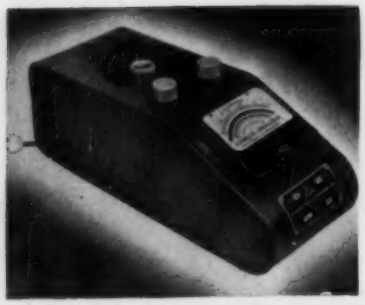
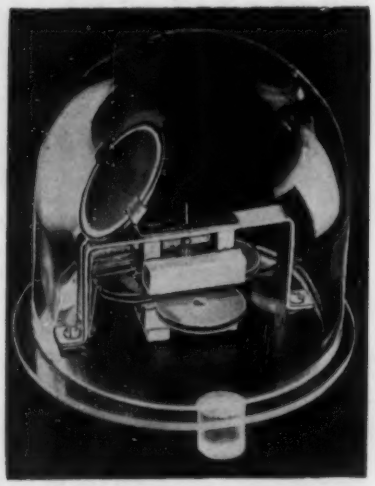


made in terms of % transmission or optical density. Instrument is supplied with bound manual containing 60 calibrations for clinical determinations, as well as detailed instructions for chemical procedures. Also available uncalibrated. — *Brociner-Mass Instruments, Inc., 1546 Second Ave., New York 28, N. Y.*

Please mention number 1163 when filling out card

Energy Conversion Motor

New solar motor is a demonstration unit to show how sunlight can be transformed to electrical energy. Light strikes 1¾" disc, is instantly changed

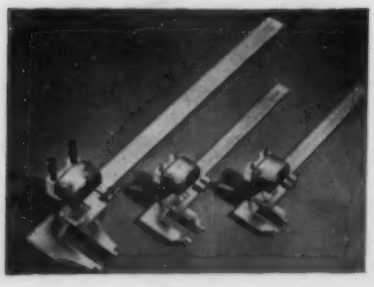


to electrical energy that operates motor. Operates on as little as 100 ft.-candles of light and produces motor speeds up to 700 rpm. in bright sunlight.—*J. Thos. Rhamstine, Box 289, Harlingen, Texas.*

Please mention number 1164 when filling out card

Magnifying Attachments for Height Gages and Vernier Calipers

New "Magna-Eye" for magnifying "hard-to-read" vernier scales fits Browne & Sharpe and Starrett calipers



and height gages. "No. 100,00 for 6" vernier calipers is equipped with 0.875" × 1.180" rectangular precision ground lens of 3½ to 4 power. Designed with a clip which fits over head of reading scale. "No. 200," for 10" height gages, is interchangeable for use also on 10" vernier calipers. "No. 300" is for 18" and 24" height gages—*Stebar Co., 711 West Lake St., Minneapolis, 8, Minn.*

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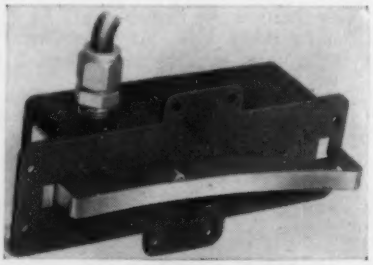
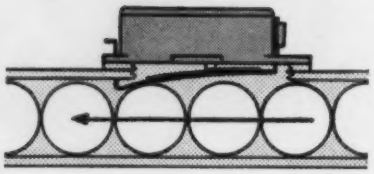
Splashproof Switch

New splashproof switch for actuating electric counters is suitable for use in chemical plants, food plants, dairies,



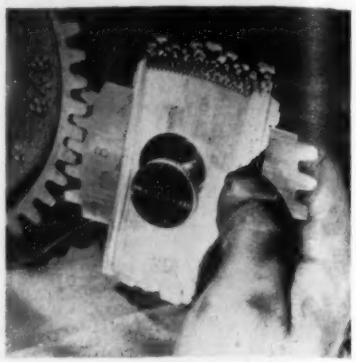


and other locations where it is likely to come in contact with water or other liquids. Case is cast aluminum, accurately machined and assembled with gasket. Fittings for waterproof cable provide splashproof electrical connection. Actuating arm is nickel silver, specially shaped to count circular objects of ¾" or more in diameter without space between objects. Arm must be depressed 3/32" for positive counter actuation. Operation requires direct force of 4.2 ounces. Flanged base with eight holes provides convenient mounting. Dimensions: length, 6"; width, 1⅞"; depth, 1-9/16, not including operating arm. — *Production Instrument Co., 702 W. Jackson Blvd., Chicago 6, Ill.*

Please mention number 1166 when filling out card

Gear Gage

New "Stainless Steel Gear Gage" (previously available only in 14½° pressure angle) is now made with

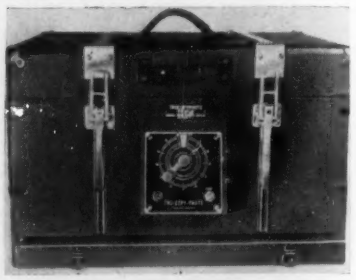


twelve 20° pressure angle full length tooth forms and twelve stub tooth forms. It eliminates tedious computation to determine pitch of gear with unknown pitch. In a matter of seconds, by rolling gage over teeth of a gear, one instantly determines the pitch.—*George Scherr Co., 200 Lafayette St., New York 12, N. Y.*

Please mention number 1167 when filling out card

Photo-copying Machine

New "Tru-Copy-Phote" photo-copying machine comes in three sizes to handle standard cuts of paper. 11" ×



16", 14" × 20", and 18" × 29". Machine takes only 15 seconds to expose autopositive paper. Built with heavily reinforced plywood, covered with washable rubberoid cloth, heavy hinges. Furnished with trays, dryer, paper, chemicals, color filter, red pilot light, squeegee board and glassware. Operates on 115 volts a.c. or d.c.—*General Photo Products Co., 15 Summit Ave., Chatham, N. J.*

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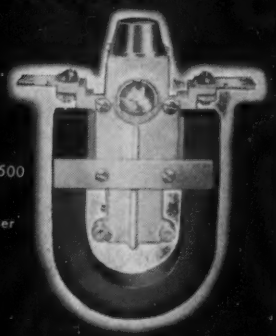

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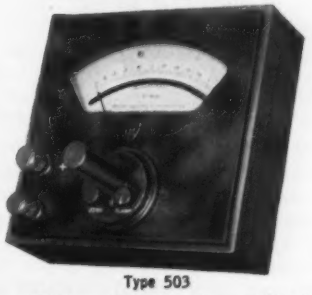

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INSTRUMENTS ON THE MARCH

Moisture Determination by Electrolytic Film

WASHINGTON, D. C.—According to Technical Report 1166 of the National Bureau of Standards, an improved method for measuring small amounts of water vapor in gases, developed by E. R. Weaver of the NBS, may also be extended to the determination of the moisture content of certain liquids and solids. The new method utilizes the change in electrical resistance of an electrolytic film as it absorbs water vapor. Such a method has the advantages of speed, simplicity, high sensitivity, and wide range. It is flexible in operation and is readily adapted to numerous applications, such as measuring the moisture-permeability of membranes, detecting minute concentrations of combustible gas in air, of oxygen in combustible gas, determining water vapor in aviators' oxygen or in liquid carbon dioxide, measuring the capacity of drying agents, determining the water content of organic liquids and solutions, and measuring the relative humidity in small or comparatively inaccessible spaces under rapidly changing conditions.

The principle of the method has for years been employed at the Bureau in various devices. A thin film of liquid, which may be phosphoric acid or a solution of sulphuric acid or other electrolytic compounds, in a gelatin or plastic binding material, is spread over the surface of a solid insulator between metallic electrodes. The electrolyte tends to reach equilibrium with the water vapor in the surrounding gas and to form a solution the electrical conductance of which is a measure of the concentration of water vapor in the gas. To utilize this phenomenon, some sensitive instrument for measuring or comparing electrical resistances and a means of calibrating the film by comparison with a gas of known moisture content are necessary. Because of polarization, alternating current must be used.

In its original form, the utility of the method was limited by the fact that the films had high temperature coefficients of resistance and did not retain their calibrations, that recalibration was a laborious task, and that no entirely satisfactory instrument was available for measuring very small alternating currents. In the development of the well-known electric hygrometer, which automatically transmits measurements of humidity from small sounding balloons in the upper air to ground stations, F. W. Dunmore of the NBS removed the first of these limitations by improving the stability of the films. However, this was done at a sacrifice of speed and sensitivity.

Finally, the wartime need for a method of determining the dryness of aviators' oxygen led the Bureau to develop apparatus permitting rapid calibration. This feature now makes possible to retain the inherent advantages of speed and sensitivity for ranges of humidity and, at the same time, to eliminate most of the difficulties caused by impermanence of calibration and changes in film conductance with temperature. In making a determination with this apparatus, either or both of the pressures of a sample of gas of known moisture content and of the unknown sample are adjusted until the have the same concentration of water as shown by equal electrical resistance of the detecting film. The water concentration of the known sample is readily computed from moisture content and volume and is, of course

Fig. 1. In the new NBS method the electrolytic film is spread over the surface of a solid insulator between metallic electrodes enclosed in a small pressure-tight enclosure (lower center). Changes in resistance of the film are indicated by corresponding current variations on the microammeter.

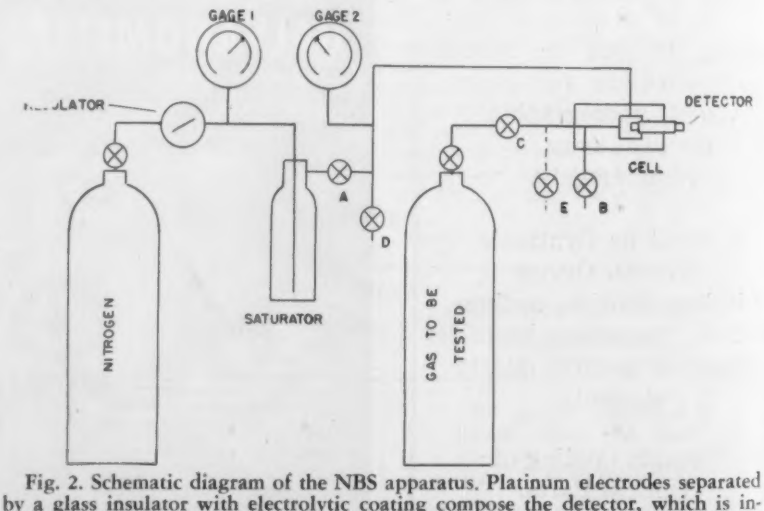

Fig. 2. Schematic diagram of the NBS apparatus. Platinum electrodes separated by a glass insulator with electrolytic coating compose the detector, which is inserted in a pressure-tight enclosure, the cell. Gas from the nitrogen tank is delivered to the saturator, where a known amount of moisture is added. The saturated nitrogen then constitutes a standard. The pressures of the two gases are now adjusted until, when each in turn is admitted to the cell, the resistance of the detector is observed to be the same, as indicated by identical readings on a current meter. The water concentration of the test sample is then equal to that of the standard, which is calculated from the pressure and water content of the nitrogen.

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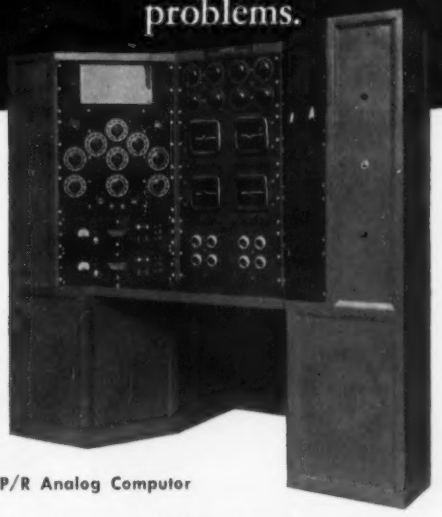

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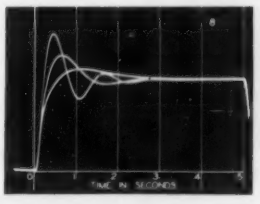

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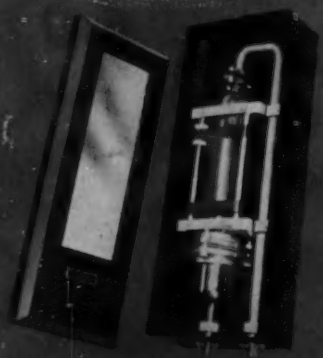

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equal to the water concentration of the unknown sample.

The improved apparatus developed at the Bureau consists primarily of a detector (electrodes and the separating insulation on which the conducting film is spread, together with the necessary support), an indicating circuit involving an adjustable bridge with its power supply and amplifying device, and an indicating instrument such as a galvanometer or microammeter. Other necessary parts are a pressure-tight enclosure for the detector known as the cell, a saturator for adding moisture to the reference gas, two pressure gages, a cylinder of compressed air or other gas, valves, and connecting tubing.

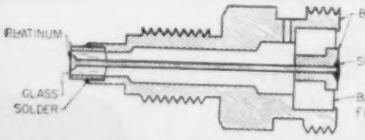

Fig. 3. Diagram of a type of "detector" designed at the NBS for rapid measurement of small concentrations of moisture in gases.

The detector consists of concentric, glass-insulated platinum electrodes, about 1.5 and 3 mm. in diameter, mounted in a bushing which can be screwed into the cell. When the gas to be tested or the reference gas is passed into the cell, the resistance of the film deposited on the surface of the glass between the two platinum electrodes varies with the moisture in the gas, and this variation in conductance is indicated by the microammeter. The pressures of the two gases being compared are then adjusted until the readings are the same. In this procedure, the pressure gages actually serve as the measuring instruments; the microammeter is used only to show a null point. However, when moisture concentrations are changing rapidly, these changes are followed by means of current readings which are interpreted with the aid of a calibration curve.

The material most frequently used for the detecting film is phosphoric acid. The gas of known water content with which the unknown gas is compared is conveniently obtained by saturating air with water vapor at high pressure and expanding to any desired extent. For humidities too low to be conveniently matched in this manner the moisture content, well below saturation, of a cylinder of compressed air is determined by comparison with air from the saturator, and the cylinder is subsequently used as a secondary standard.

It has been found practicable for an observer using this method to determine the compliance of oxygen with an exacting specification for dryness at the rate of 100 cylinders per hour. By use of secondary standards with some sacrifice of accuracy, it is possible to work with greater speed and convenience as well as at much lower concentrations of water vapor. Changes of less than one part per million of water in Freon from a refrigerating machine have been determined in this way without difficulty at intervals of one minute.

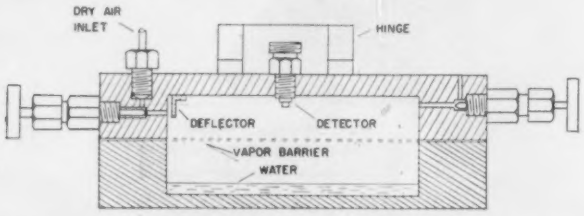

Fig. 4. Diagram of NBS apparatus. The vapor barrier to be tested is clamped over an enclosed container of water at a short distance above the liquid surface. At the top of the enclosed space above the barrier is the detector. The resistance of the detector is first measured at a relative humidity of 25 percent. The detector is then inserted (as shown), and the space above the barrier is swept out with dry air for one minute, after which the valves are closed. The time required for the relative humidity of the space to again reach 25 percent, as indicated by the electrical conductance of the detector, is a measure of the resistance of the membrane to the passage of moisture.

A simple and convenient auxiliary apparatus has been designed at the Bureau, by means of which this method may be used to determine extremely small concentrations of water in such liquids as ether or gasoline in a few minutes. Since the water concentration of a liquid of otherwise constant composition bears a definite relation at any given temperature to the humidity of air with which it is in equilibrium, the moisture concentration of a liquid may be quickly determined by measuring that of the air above it. A spring clip is applied to the detector so that a glass test-tube with a small opening in the bottom may be quickly attached, making a snug but not air-tight fit with the detector plug and covering the sensitive film. When the detector with this attachment is lowered into a bottle of the liquid to be tested, the glass tube fills with liquid from well below the surface at a rate which forces air past the detector under slight pressure. The detector is lowered until the detecting film is only a few millimeters above the liquid surface. The resistance of the detector changes rapidly at first but soon becomes practically constant when the small volume of residual air becomes saturated. Since this volume is almost isolated from the surrounding

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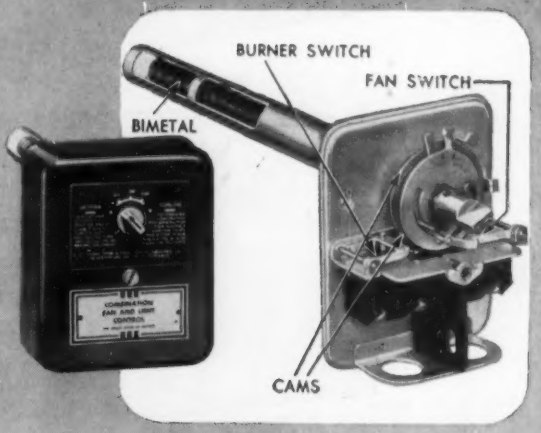

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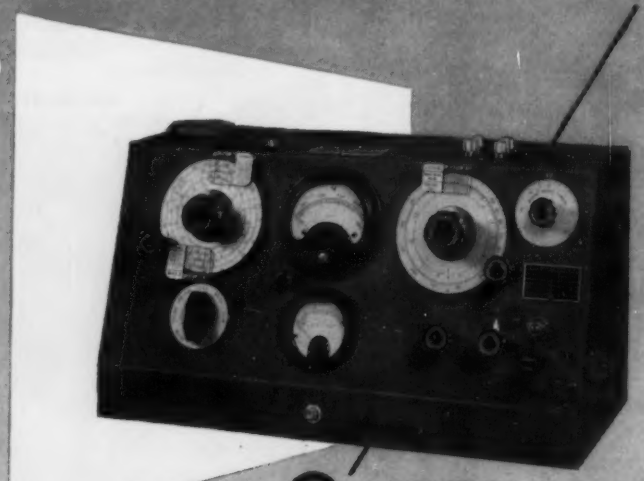

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atmosphere, which is itself almost in equilibrium with the liquid, there is little disturbance by diffusion from the outside. Two or three minutes is usually sufficient to obtain a steady reading, and successive tests are reproducible.

The instrument appears to be applicable to almost any liquid; with those which produce alkaline vapors, however, an electrolyte other than phosphoric acid must be used. It is expected that this device may also prove useful in determining the moisture content of many substances—such as fats or cellulose derivatives—which are soluble in organic liquids.

The general applicability of the method to liquids suggests the possibility of determining water in solids. Candy can be dissolved in alcohol, butter or other grease in ether or carbon tetrachloride, and the water in the solutions quickly determined. A sample

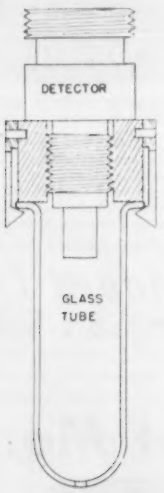
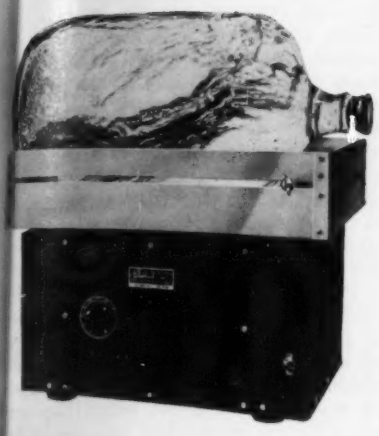


Fig. 5. Diagram of NBS device designed for rapid determination of small concentrations of water in organic liquids. This is done by measurement of the moisture concentration of air in equilibrium with the liquid. The detector is as shown in Fig. 3. By means of a spring clip the glass tube (with a small opening in the bottom) may be quickly attached, making a snug but not air-tight fit with the detector plug and covering the sensitive film. This assembly is lowered into a bottle of the liquid to be tested.

of soil, molding sand, or concrete-making material shaken with acetone may be expected to transfer its surface moisture to the liquid at once. Thus it should be possible to determine quickly the surface moisture of numerous powdered or granular solids by shaking a measured sample with a suitable liquid and, without removing the solid, submerging the attachment for testing liquids in the resulting solution.

By passing dry air at a steady rate through a powdered solid and thence through the measuring cell while the resistance of the detector is recorded at short intervals, the amount of water removed from the solid may be estimated. This procedure, as contrasted with differential weighing, has the advantages of speed, sensitivity, and



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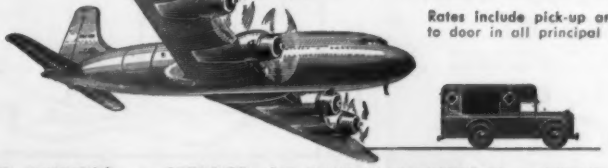

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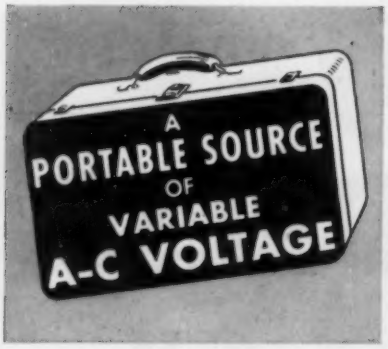

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smallness of sample required. A similar procedure, in which saturated air is passed over a desiccant, has been found useful in determining the capacities of drying agents.

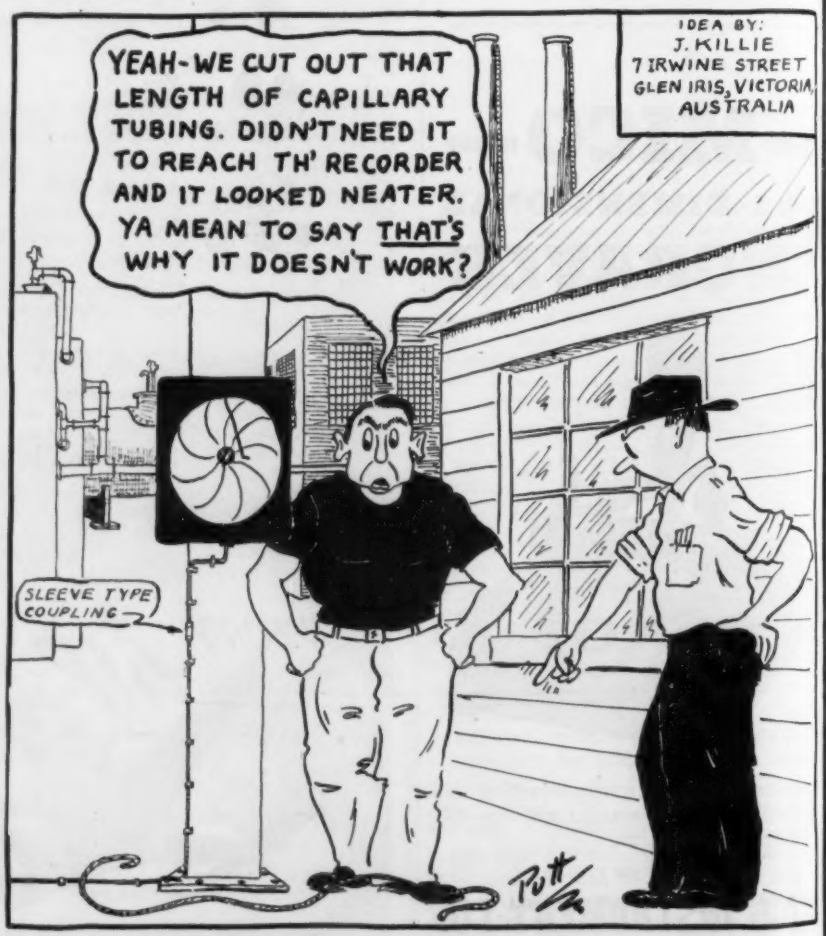
The permeability to water vapor of protective films or membranes used in packaging materials for shipment or storage is of considerable importance. The quick response of the detector to low concentrations of water in small samples adapts it to the rapid determination of permeability—not only to water, but when combined with combustion, to oxygen, hydrogen, and other substances that can be burned to produce water. The vapor barrier is clamped over an enclosed container of water at a short distance above the liquid surface. Above the barrier is an enclosed space, at the top of which is the detector. This space is connected through valves to a supply of dry air and to the outer atmosphere. Before inserting the detector, its resistance is determined in the usual way at a relative humidity of 25 percent. It is then placed in the space above the vapor barrier, and the space is swept out with a brisk stream of dried air for one minute. After the valves are closed, the time required for the relative humidity in the space to again reach 25 percent is an indication of the resistance of the membrane to the passage of moisture. In this way, the permeability to water vapor of a square inch of ordinary cellophane can be determined approximately in less than one minute after closing the valves. An advantage of this procedure is the possibility of testing very small samples of the protective barrier.

The detector has been employed, in combination with a hot platinum wire to cause combustion, for the detection of combustible gases, most of which produce water when burned. Its speed of reaction and great sensitivity suggests its use in locating leakage of fuel gas, exploring for petroleum, and detecting explosive mine gases.

The device is not satisfactory at very high humidities and is not recommended for ordinary meteorological observations, where the instruments commonly used are less elaborate and will give as good or better results with the same attention. However, the method does have the advantages of speed of response, broad range, and ability to measure the humidity of small spaces

WHEN A FELLER NEEDS CONTROL

By Phil Putnam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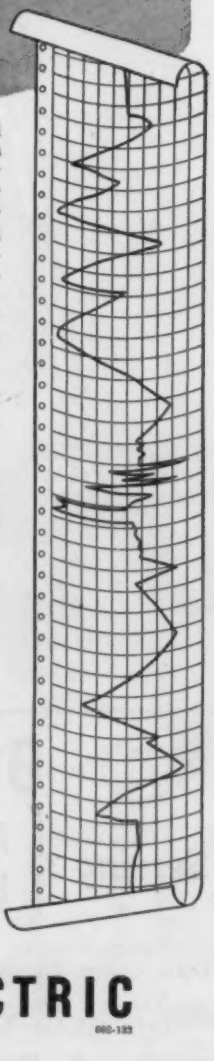

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H-v. X-ray Energy Distribution Plotted

SCHENECTADY, N. Y., Oct. 24—A new device for measuring the energy distribution of 100,000,000-volt x-rays produced by the giant betatron in the General Electric Research Laboratory here, has been announced. Dr. James L. Lawson, research associate, describes it in a paper in the October issue of the *General Electric Review*. Using the new technique, he declares, it has been possible to obtain in a few months data which would have required 300 years working time by older methods.

Though the betatron can produce x-rays of as much as a hundred million volts energy, the radiation is not uniform, but consists of a mixture of various energies up to the maximum. It can be used to alter atomic nuclei in "atom smashing" experiments, and for accurate experimentation it is essential to know the exact energy distribution of the rays; that is, their spectrum.

Some secondary process must be used to accomplish this, explains Dr. Lawson. The most satisfactory one yet found is the process of pair formation in which the x-ray photon is changed from energy to matter. It turns into an electron, with a negative electrical charge, and a positron (positive charge).

Pair formation has been used for a number of years in the measurement of energies of cosmic rays, he added, though its application to precise measurement of x-ray intensity had not previously been achieved.

A beam of light can be passed through a prism, thus forming a spectrum. The brightness of various colors from the lowest energy red waves up to those of blue and violet, shows their distribution in intensity. The ultraviolet spectrum may be recorded on a photographic plate. The low-energy x-rays (those of a few hundred thousand volts or less) can be dispersed by the closely-spaced molecular planes in a crystal. With higher-energy radiation, however, use of a crystal is impractical. Thus a secondary effect, such as that of pair formation, must be employed.

Electron-positron pairs may be produced by bombarding a thin metal target with a beam of gamma rays, virtually all their energy reappearing in the secondary particles. If these are passed through a strong magnetic field the positron is curved to one side and the electron to the other, the curvature being greater for pairs of lower energy. The paths of such pairs may be recorded photographically in a cloud chamber, where the tracks are shown by a thread-like trail of fog in moist air

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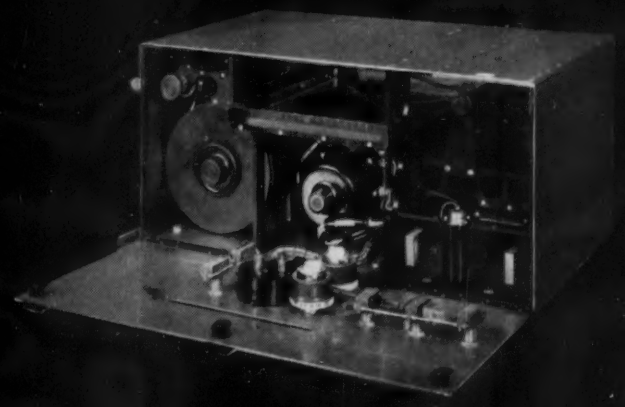

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New DU MONT TYPE 250 CATHODE-RAY OSCILLOGRAPH

THE APPLICATION...

The examination of a machine component for its reaction under shock-load conditions is best accomplished by cathode-ray oscillography. What characteristics must the oscillograph possess?

OSCILLOGRAPHIC CHARACTERISTICS REQUIRED FOR THIS APPLICATION . . .

1. Single sweep, continuously variable in duration. The single sweep of the Type 250 is continuously variable from 1 second to 20 microseconds.

2. Adequate light output. The Type 5CP-A Cathode-ray Tube in the Type 250 operates at 3000 volts accelerating potential for brilliant traces.

3. Wide-band amplifier. Type 250 provides either d-c to 200 kc at better than 1 d-c volt/in., or 5 cps to 200 kc at better than .02 rms volt/in. sensitivity.

4. Automatic beam blanking, so that the beam is on only when signal is present. This too is a feature of the new Type 250.

IF QUANTITATIVE MEASUREMENTS AND PERMANENT RECORDS ARE REQUIRED . . .

1. A voltage calibrator that can be switched in ahead of attenuator and gain control of Y-axis amplifier, must be available. A voltage-calibrator is built into the Type 250.

2. Provision must be made for photography. Types 271-A and 314 Oscillograph-record Cameras fit the type 250 without modification.

. . . AND SO THE NEW TYPE 250!

Because it meets ALL those requirements as a general-purpose oscillograph. More than that, it embodies many additional features that facilitate the application of cathode-ray oscillography to mechanical problems. A variety of input connections; d-c and a-c amplifiers; either single or recurrent sweeps; choice of long- or short-persistence phosphors, together with Z-axis modulation—such spell *maximum* usefulness.

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DUMONT

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which is suddenly expanded. The pair are identified by oppositely-curved tracks emanating from a common origin.

"The essential difficulty of the cloud chamber method" writes Dr. Lawson, "lies in the large number of pictures necessary to make the determinations statistically accurate. Not only is the obtaining of an adequate number of records an arduous and time-consuming undertaking, but the task of analyzing the photographic data is a forbidding one."

In the Lawson apparatus, which was constructed under the sponsorship of The Office of Naval Research, electron-positron pairs are produced at the target and curved by passage between the poles of a powerful electromagnet. They are detected by a battery of 100 Geiger-Muller counters, arranged in two sets on either side of the direct beam, one counting electrons, the other positrons. In each series the counters are spaced and connected in groups representing distinct and equal energy intervals. Because electrons and positrons are quickly scattered in air, their entire path from target to counters, is inside a large tank, evacuated to a pressure of less than a ten-millionth of atmospheric. The whole unit weighs about eight tons but is made mobile because it is mounted on trucks.

Through a tabulating circuit utilizing some 300 vacuum tubes, the counters are connected to a bank of registers which shows directly the spectrum.

"A great advantage of this system," declares Dr. Lawson, "is the large amount of data that can be taken and analyzed in a relatively short time. In intermittent working periods over a six month interval, a total of approximately 10,000,000 pairs have been registered and analyzed. To obtain and process an equivalent amount of data by conventional cloud chamber methods would require about 300 years of actual working time."

He is now preparing a discussion of the experimental results for publication in the *Physical Review*.

Trillionth of Atmosphere Vacuum Measured

PERTHSHIRE, Scotland, Oct. 12.—A vacuum so high that all but about a trillionth of the atmosphere has been removed, can be measured with relative accuracy, Dr. Saul Dushman, assistant director of the General Electric Research Laboratory of Schenectady, N. Y., reported here today.

He spoke at the High Vacuum Conference, sponsored by the Society of Chemical Industry. Author of a new book, "Scientific Foundation of Vacuum Techniques," which will be published in December, Dr. Dushman was invited to open the conference with a review of methods for producing and measuring high vacua.

As a result of wartime demands, he

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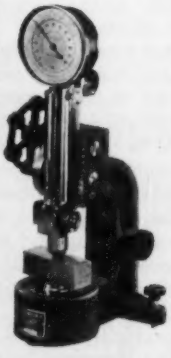

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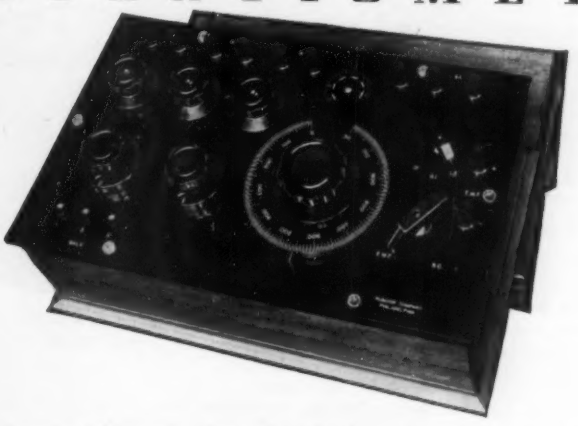

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2. Three reading dials—effective scale length of approximately 175 feet for each range. Readings easily estimated to within one part in 100,000 of full-scale ranges.
3. Subpanel switch and slidewire construction for protection of contacts from dust and corrosive fumes.
4. Special provisions to minimize parasitic thermal emf's—including automatic compensation of slidewire thermals and gold contacts in galvanometer key.
5. Exceptional convenience in reading and adjustment.
6. Solid and substantial construction for many years of trouble-free service.

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Rubicon galvanometers suitable for use with the Type B Potentiometer are described in Bulletin 320.

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said, "vacuum pumps were developed which have speeds, even at the low pressure of one millionth of an atmosphere, much beyond any figure realized even ten years ago.

"Vacuum technique," he added, "has emerged from the laboratory and the methods of the glassblower to that of an industrial field in which the engineer and the metal welder play an important role. . . . The recent war served to bring out new devices such as the magnetron and fluorescent-screen cathode-ray tubes, now widely used in television receivers.

"While the early form of Coolidge x-ray tube was designed for a maximum of 100,000 volts," he continued, "subsequent developments in design of both the tube and the high-voltage transformer have made it possible to increase the range of operation to obtain x-rays corresponding to two million volts. Such tubes have proved useful both in therapeutic work and in the inspection of very heavy metal plates and castings.

"The development and application of electron diffraction in purely scientific investigation and of the electron microscope have been made possible by means of high vacuum technique. This has also led to the production of high-energy particle accelerators, such as the cyclotron, betatron and synchrotron.

"The accurate determination of nuclear masses by the mass spectrometer, another vacuum device, has yielded fundamental data for the verification of the Einstein mass-energy relation. More recent application of this device in gas analysis and as a leak-detector have proved invaluable."

New Method For Measuring Lens Response

DETROIT, Oct. 23—A new degree of realism in television, motion pictures and still photography may result from a new method of measuring contrast characteristics of both optical and electrical lenses which was described today to members of the American Optical Society at their convention in the Hotel Fort Shelby here.

The procedure, developed by Otto H. Schade, advance development engineer of the Tube Department of the Radio Corporation of America, is also applicable to contrast measurements for different types of photographic film and television screen materials.

Employing what is essentially a television pick-up and reproduction system, it provides the first known practical method of analyzing and rating the ability of various types of lenses to show picture detail.

The theorical values by which lenses have been rated heretofore, Mr. Schade explained, are based on their power of resolution—the greatest number of lines per millimeter. However, useful resolution for photography and television are limited, respectively, by the response

REQUIRE A VACUUM TIGHT JOINT BETWEEN GLASS AND METAL TUBING?

Cerroseal-35 will do the job quickly and permit taking apart easily.

The procedure: tin inside of metal tubing to depth of joint, using any flux. Wash off all flux. Tin outside of glass tubing by wiping molten alloy on tubing, which has been warmed to alloy's melting point, about 244° F. Warm both parts to be joined to give an appearance of wetness and insert glass tube into metal tube. Flow excess alloy into joint to completely fill space and allow to cool. Recommended alloy film thickness—.002″ to .004″.

Corroseal-35 is one of a series of interesting and useful Indium alloys having very low melting temperatures.

They are:	Melting Temperature
Cerrolow-105	*105°F
" -117	117°F
" -136	136°F
" -147	*147°F
" -174	174°F
Cerroseal- 35	*244°F
" - 25	*294°F

*Non-eutectic alloys—yield temperatures are those given.

Suggested and actual uses. Fusible links in automatic fire alarm and extinguisher devices; in manual reset thermal switches for controlling processing; or for signalling rise of temperature, as in bearings; thermal safety controls in refrigeration, diathermy and electronic equipment. As a proof casting medium for delicate machine work, Cerrolow-117 can be poured without fear of over-expanding metal parts and shrinks but .0002″ per inch after casting.

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It is available in the 2½″, 3½″, and 4½″ dial sizes and mounted in a black enameled, deep steel case. Write for details and price.

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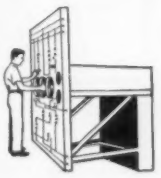

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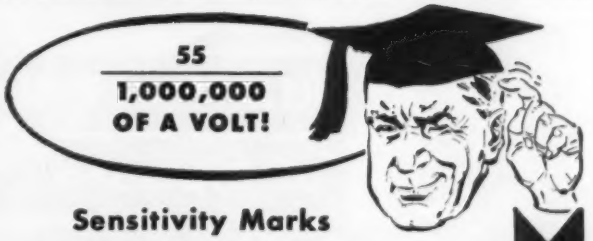

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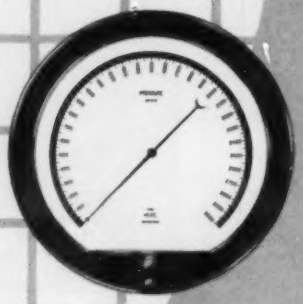

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The scales of Heise Bourdon tube pressure gauges are absolutely concentric with the pointer rotation. Errors due to misalignment in mounting or cutting the scales are avoided since the scales are cut from their centers, and are mounted at the centers on a hollow spindle through which the pointer rotates.

Three sizes: 8½ in., 12 in., and 16 in., in ranges from 0-15 to 0-10,000 psi. Prices from $151.60 to $211.20. Write for catalog.

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of photographic film and the width of television frequency channels. To improve picture detail within these limitations, the research engineer in these fields must strive for sharper contrast of light and dark picture elements within lower ranges of resolution—about fifty lines per millimeter in photography and ten lines in television. The system developed by Mr. Schade affords the first practical means of determining the contrast response of lenses in these ranges, or in any specified range from zero to the limiting resolution.

The equipment consists essentially of a specimen mount, a lens mount, a microscope, a television camera, a television picture tube or kinescope, and an oscilloscope, arranged in that order. A test pattern made up of a series of vertical and horizontal lines of diminishing size and spacing is mounted before the lens to be rated, and a greatly reduced image of the pattern is produced. The microscope enlarges this image before it is picked up by the television camera, providing a large, easily-studied televised image on the kinescope, and a large, accurate wave-form image on the oscilloscope.

Using this wave-form as a basis, Mr. Schade has worked out a system for plotting curves on a chart to show the contrast or detail response of a given lens at any degree of resolution. Similar ratings for the electrostatic or electromagnetic lenses used in television camera tubes can be charted by an application of the same principle, while ratings for similar lenses in kinescopes are established by a modification of the system employing RCA's "flying spot" scanning tube to analyze the kinescope image.

"The trace on the oscilloscope can be calibrated quickly, easily, and accurately" said Mr. Schade, "by focusing on the photo surface of the television pick-up tube a measured amount of light sufficient to cancel one of the dark lines in the kinescope image. This is done by mounting a small mirror at an angle to superimpose the light slit image on the test pattern image, and by using a phototube to measure the amount of light required for cancellation.

"A general method has been worked out for measuring and plotting the detail response of lenses, film, and television imaging devices in the form of curves showing all values of detail response from zero to the limiting resolution, and for various angles and colors of light.

"A simple method is also provided for finding the over-all response of systems in which several imaging processes occur, such as a motion-picture process involving camera lens, film, and projection lens, or an even more complicated television process where a scene may be picked up by a camera lens, transformed into an electrical image by a television picture tube, limited in resolution by an electrical channel, reconstructed as an optical image by a kinescope, and projected by an optical lens to a viewing screen."

JOURNAL of the Instrument Society of America

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Vol. 3 — November 1948 — No. 11

General News

MEMBERSHIP AND SECTIONS COMMITTEE

This committee is the first to send the editor a report on its work in Philadelphia. The report is not being published here to have space and because the committee's recommendations have not been approved. The final report with approval of the Board of Directors will appear in these columns when it is available.

The committee worked on such things as Student and Foreign Memberships. The benefits automatically included in the dues of Members and Associate Members also received needed study. Subcommittees were established to study some of these problems further.

NEW YORK SECTION TO HOLD SECOND SPECIAL MIDWINTER MEETING

Advance information has been received relating to a special mid-winter meeting of the New York Section, to be held January 28 and 29 at the Hotel Pennsylvania, New York, on the general subject of "Modern Pressure Instruments and Measurements." The meeting will follow the same pattern found successful at the ISA mid-year national meeting held at the same place last winter. The meeting follows the annual meeting of the Institute of Aeronautical Sciences (ending January 28) and precedes the week-long winter meeting of the AIEE starting January 31.

Two technical sessions will be held Friday, January 28, followed by a dinner in the evening. The keynote of the meeting will be sounded by the chairman of the morning sessions, W. G. Brombacher of the National Bureau of Standards, "Some Problems in the Precise Measurement of Pressure." This will be followed by other speakers on pressure instruments, measuring methods and industrial applications during the day. The program, which will be published in detail in the next issue of the Journal, includes papers on high pressure measurements and those of absolute and differential pressures. Stress will be placed on recent development and the problem of obtaining more accurate measurements. Papers on high pressures and vacuum measurements, and on dynamic measuring techniques, dealing with blast and engine pressures, are included in the plans.

The Saturday morning session will deal with the study of instruments for static pressure measurements, such as static, bourdon and sylphon types of pressure elements, as well as differential arrangements, such as pressure, liquid manometer, oil-sealed and the aneroid types. During the afternoon session servicing special types which entail diaphragms, absolute pressure gages, barometers, etc., will be taken up. The final part of the afternoon session will be a discussion of how to set up a service bench or shop, on a small scale, to handle adjustments, repair and calibration of common industrial instruments.

This meeting is a special conference event arranged by the New York Section as a continuation of the program started last year. Hotel accommodations have been reserved in the name of ISA at Hotel Pennsylvania for the convenience of out-of-town attendance, and it is especially to be noted that members of any ISA section and others interested will be welcomed. Correspondence should be addressed to New York Section, ISA, Box 608, Merrick, L. I.

Section News

This month a slight change is being tried. Not all sections send in reports of their meetings so, if only those reports are published, some sections receive no mention in these columns. Some sections send only their meeting announcements and no report after the meeting is held. In past issues I have sometimes written a report from the announcement but this is a dangerous practice because the listed speaker is sometimes replaced at the last minute.

So this month I have tried to write something about each section, if I received anything at all. In the following "reports," the signed paragraphs were sent in by the correspondents or secretaries. The unsigned ones were written, for completeness, by the editor.—H.L.H.

ARUBA

The Aruba Section held its 25th regular meeting on October 6, 1948, at the Engineers' Club.

The most important business of the evening was the election of officers who will take office the first meeting of 1949. Those elected were:

President, W. F. Hughes; *Secretary*, A. S. MacNutt; *Treasurer*, D. Fryback.

Chairman of Committees: *Program*, J. L. Lopez; *Entertainment*, M. W. Morris; *Housing*, E. L. Wilkins; *Membership*, W. A. Koopman; *Publicity*, W. Learned; *R. P. C.*, M. R. Holly.

The rest of the business was routine, after which, we enjoyed two sound films titled "Asphalt Paves the Way" and "Fire Fighting," which were loaned us by the Training Division of Lago Oil & Transport Co., Ltd. —M. R. HOLLY, *Sec'y*

CALIFORNIA

This section was busy in October. The Oct. 5 regular meeting was scheduled at Statham Laboratories for a talk on "Applications of an Electrical Transducer to Instrument Design." Also, at this meeting, the balloting on the Section's new Constitution was to be announced. Incidentally, the constitution committee worked hard and turned out a fine job.

On Oct. 21, a special meeting was scheduled to present the film "Atomic Physics" produced in England. The film begins with the discovery by Dalton of the Law of Constant Proportions, about 1800, and traces the discoveries of Cathode Rays, Canal Rays, X-Rays, the Electron, Radioactivity, the Mass Spectrometer, the Neutron, down to recent work with Induced Radioactivity and the Atomic Bomb.

The film's scientific accuracy is attested by the fact that it was produced in collaboration with such individuals and organizations as Prof. Albert Einstein, Prof. J. D. Cockcroft, The Royal Society, The Royal Institution, and the Cavendish Society.

CHARLESTON

Opening the 1948-49 season, the first fall meeting was held October 4 at the Woman's Club. Forty members attended dinner preceding the lecture. At the business session before the feature of the evening, Mr. H. J. Bowman, Alternate National Delegate, reported on the meetings in Philadelphia at the time of the National Instrument Conference. All the technical societies in the valley were invited for this "Basic Control Instrument Demonstration." Mr. R. N. Pond, Application Engineer for the Taylor Instrument Companies, used a large stage model strip-chart recorder to show the effect of each control element. Assisted by Mr. R. Brostedt, the speaker varied the type of control, adding proportional response, automatic reset and preact as the process requirements were changed.

On November 1, "Fundamentals of Electrical Measurements" will be the subject of a discussion by Mr. S. B. Spracklen, Special Instrumentation Department, Instrument Division, Carbide and Carbon Chemicals Corporation, South Charleston Plant. This will be a non-technical description of the circuits used in d-c. measurement.

—MARY K. ADAMS, *Corr.*

CENTRAL INDIANA

The Ripple Aires Quartet entertained the section at its October meeting and Mr. Fred H. Sauer of P. R. Mallory Co. gave a talk on the use of the spectrograph in metallurgical research.

Sr. Francisco Araos of Lima, Peru was a distinguished guest. —E. E. TAYLOR, *Corr.*

CHICAGO

Two meetings are scheduled for November. "The Use of Instruments for Inspection and Quality Control" on Nov. 1, at the Builders' Club and "Flow Meter Installations" and "Control Valve Installations" at the Peoples Gas Auditorium on Nov. 15.

The October meeting broke attendance records according to "Events" the section

publication. This was a joint meeting with the Northern Indiana and South Bend Sections. The program was a panel session on "Chemical Plants and Petroleum Refineries —Instrument Installation and Maintenance."

KANSAS CITY

On September 28, 1948, the Kansas City Section met at "The Crossroads," with 34 members and guests present. Mr. R. A. Schoenfeld, Vice President, Wheelco Instrument Company of Chicago, Illinois, presented an illustrated talk on "Wheelco Systems as Employed in the Various Pyrometers and Flame-controls." Mr. Schoenfeld covered the basic principle operation of Millivolt Meter Instruments, and the operating principles of the Wheelco Throttitrol, Inputrol and their new Electronic Scriber.

—W. A. REICHOW, *Corr.*

LOUISVILLE

Mr. Robert M. Cundiff, Cincinnati District Manager of the Bailey Meter Company, was the principal speaker at the Sept. 28 meeting. Mr. Cundiff covered rather broadly the subject of power plant measurement and control. By means of slides he demonstrated primary measuring elements, typical installations for boiler control, and outstanding panel board arrangements. Most of our members have a rather skimpy knowledge of this subject, and we found it very interesting and informative.

Mr. Melvin Johnson, Treasurer of the Louisville Section, gave a report on the recent National I.S.A. Meeting in Philadelphia. In the absence of President Joseph Monahon, Vice President Estus Ballard presided.

—P. B. SMITH, *Sec'y.*

MONTREAL

The first meeting of the season was held on September 27 with record attendance. The speaker of the evening, H. W. Stoll of the Taylor Instrument Company, discussed "Flow Measurement," a highly interesting paper which promoted an active question period. Mr. Hall of the Foxboro Company attended and outlined I.S.A. progress towards developing instrumentation curricula.

At the close of the session an announcement was made that a trip to the Imperial Oil Refinery, Montreal East, and a talk on catalytic cracking and the instrumentation involved would be arranged for the next meeting.

—GEORGE RICE, *Corr.*

NEW YORK

The New York Section has changed its meeting announcement form. After three years of using a printed form, they have gone to a folded sheet produced by mimeograph. The results are pleasing and the announcement contains interesting news bits, a list of new members, etc. Those sections still spending considerable money on printing might well follow this line too.

NIAGARA FRONTIER

The regular meeting of the Niagara Frontier Section was held Monday evening, Sept. 27, at 8:00 P.M., at the New York State Institute of Applied Arts & Sciences. A short business meeting was held during which it was announced that Buffalo had been selected as the host for the 1950 I.S.A. convention.

Mr. O. V. Guenther, Mechanical Engineering & Metallurgy Labs, New York State Institute of Applied Arts & Sciences, spoke for a few minutes describing the work which had been done toward setting up a course of Instrumentation at the Institute. A considerable amount of equipment has been purchased for use in the Laboratory, which is being prepared for this course, and Mr. Guenther announced that he would be very much interested in receiving applications from men who could satisfactorily qualify as an instructor in this course of Instrumentation.

President Boltz then introduced the speaker of the evening, Mr. Kermit Fischer, President of the Fischer & Porter Co. of Hatboro, Pennsylvania. Mr. Fischer, backed by many years of experience in the development of flowmeters, was exceptionally well qualified to speak on his subject, "Neglected Aspects of Fluid Dynamic Theory as Applied to Fluid Meters." Mr. Fischer presented a definitely convincing case for the variable area type Flow Meter, as compared with the familiar pipe line orifice. He indicated that the annular stream around the plug or float in an area type meter is more uniform than through an orifice; that the total head may be measured with the variable meter as compared with the velocity head only being available for measurement with orifice taps. A very interesting point concerning the variarea type flowmeter, as compared with the mate use be applied to the measurement of a corrosive gas at high temperature, the meter can easily be calibrated, using a noncorrosive gas at a low temperature. Mr. Fischer also stated that a comparison of the Reynolds numbers, derived from the ratio of Drv, in which "D" equals pipe line

M

diameter, "r" equals density, and "v" equals velocity over viscosity, 10,000 is the minimum Reynolds number with which stabilized flow can be obtained with a pipe line orifice, stabilized metering can be obtained with Reynolds numbers as low as 80, using the variable area type meter.

—W. J. SOMMERS, *Corr.*

OAK RIDGE

The Oak Ridge Section held its 29th meeting at Ridge Recreation Hall, October 6. The first portion of the meeting was given over to our National Delegate, N. L. Isenhour who gave an excellent report on the recent Philadelphia Exposition.

Following a rather heated discussion regarding proposed constitution amendments the speaker of the evening was introduced, Mr. C. H. Barnard, Applications Engineer of the Bailey Meter Company. His topic, "Engineering Development and Application of Electronic Type Instruments and Control Systems in the Improvement of Process Operations," was most ably presented.

By means of slide projections various circuits and applications were explained in detail. Mr. Barnard's wartime service in applying automatic control and electronic type instruments to merchant and naval vessels aroused much interest.

—J. O. ALEXANDER, *Sec'y.*

PHILADELPHIA

The Oct. 20 meeting is scheduled to have an intriguing subject "What Management Expects of An Instrument Department." The speaker is to be Mr. R. R. Jackson, General Manager, Socony-Vacuum Oil Co., Paulsboro, Refinery. Also, a new slate of officers is to be elected.

PITTSBURGH

With its first regular meeting of the 1948-49 season, the Pittsburgh Section has returned to the Blue Room of the Roosevelt Hotel for its dinner and meeting. On Sept. 27, 42 members and guests gathered for dinner at 6:30 P.M., and several more arrived by the time the meeting opened at 8:10 P.M.

The minutes of the May meeting were approved as read by the Secretary, who also announced that Louise Suckfield was the new Editor of Pittsburgh Headlines and that the Section now had 180 members, including 30 students. The treasurer then presented his report of current Section finances.

The National Delegate, Mr. A. H. Shafer, gave an excellent report on the recent Instrument Fair and National I.S.A. meeting. Over 13,000 visitors attended the Fair, and 42 Sections, with 3275 members represented at the Board meeting. He described many details of the meeting, including the election of our past-President S. W. Prince as Chairman of the National Historical Committee.

M. S. Jacobs reported on the work of the Sections Committee, which acts as liaison between the Sections and the National Office. C. B. Cochrane, reporting for the Section's educational committee, announced that the new session of the course on instrumentation at Connelly Trade School has opened, with 50 men registered. This was followed by introduction of the Executive Committee and Committee chairman. The meeting recessed for refreshments—beer and coke. The last feature was a Westinghouse sound motion picture entitled "Radio Frequency Heating". It illustrated the principles and applications of both induction and dielectric heating. The meeting was adjourned at 9:50 P.M.

In addition to the regular monthly meetings on Mondays, the Section is holding four Friday night meetings in several neighboring industrial centers. The first of these was held on Sept. 24, at Steubenville. Mr. F. C. Sweeney, of Weirton Steel Co., spoke on "Instruments and Controls Applied to Reheating and Heat Treating Furnaces."

—M. M. FROMM, *Corr.*

SAINT LOUIS

The first meeting of the 1948-49 season was held on Wednesday, Sept. 29, 1948, at the Engineers' Club in St. Louis. Speaker of the evening was Mr. W. H. Pugsley, Vice President in charge of Field Research for the Hays Corporation, Michigan City, Ind., whose subject was "Electronic Type Recording Instruments for Oxygen, Carbon Dioxide, Temperature and Pressure."

The system of measurement consists of a sensing element which is connected as one arm of a Wheatstone Bridge circuit. The bridge is balanced by means of a motor driven rheostat that is operated by the output of an amplifier that is sensitive to the unbalance of the bridge. As soon as the bridge is in balance, the voltage input to the amplifier is zero, the output is zero, and the motor driven rheostat stops. Reversal of unbalance of the bridge will cause reversal of phase of the amplifier voltage output causing reversal of motor rotation. The motor shaft carries a cam which actuates the pen of the recorder, thus making available desirable chart characteristics. The pen will not be at rest unless the bridge circuit is in balance.

The sensing element must be one that changes its resistance when the measured quantity varies. It may be a resistance thermometer, heated wire for gas analysis applications, Statham strain gauge for strain or pressure measurements, etc. A large amount of power is available to drive the pen and associated mechanisms, high sensitivity is obtained due to the high amplification. These instruments should have a wide application in measurement and control.

The following are the officers of the St. Louis Section for the 1948-49 season, ending June 30, 1949:

Chairman: Landon C. Lodge, C. K. Williams Co., E. St. Louis, Ill.; *Vice-Chairman:* Harry U. Fisher, Monsanto Chemical Co., St. Louis, Mo.; *Secretary:* Wm. G. Lee, National Lead Co., St. Louis, Mo.; *Treasurer:* C. H. Young, Socony-Vacuum Oil Co., E. St. Louis, Ill. *Program Chairman:* Ed. Ronsick, Economy Equipment Co., St. Louis, Mo.; *Membership Chairman:* J. T. McFarland, Hagan Corp., St. Louis, Mo.; *Employment Committee Chairman:* Wm. K. Volz, Monsanto Chemical Co., St. Louis, Mo.; *Chairman 1949 National Meeting:* Phil R. Watson, St. Louis, Mo.

The next regular meeting will be held on Nov. 3, 1948, at the Engineers' Club in St. Louis. The speaker will be M. J. Boho of Hagan Corporation, the subject "Steel Mill Controls." The December meeting will be a joint one with the AIEE and St. Louis Engineers' Club; the speaker will be Dr. Becker of The Bell Telephone Laboratories.

H. E. ZEFFREN, *Corr.*

SOUTH TEXAS

After a summer vacation from the monthly routine of meetings, the South Texas Section met on Oct. 5. The meeting was held in the new Blue Bonnet plant of the Corn Products Refining Co., which is Corpus Christi's newest big industrial plant. The plant is still under construction; but from what we saw of it, we are sure that it will be an interesting place to work, and a must on the list of places to visit while in Corpus Christi.

Committees were appointed to plan our annual winter dance, and for the nomination of new officers for 1949. Secretary Homer Givens gave a report on his trip to the National convention, and was ably assisted by Mr. B. B. McMullen, the local Marchant merchant, and by Corn Product's own Mr. Pierson, in describing the exhibits.

(Continued on Page 1058)

Supervisory Control Systems*

By LOUIS GESS and ROBERT M. HUTCHINSON**

Introduction

IN MANY refineries the batch type of crude still is often observed adjacent to the most modern type of catalytic cracking unit. Instrumentation originally used for the operating of batch type stills was primitive indeed compared to present day practices. It was generally found sufficient to provide indications of pressure and furnace draft, and possibly a record of the batch temperature. The units were so small that location of instruments and their observation did not present any problem.

For many reasons, many industries continue to use batch processes exclusively or for parts of their process: continuous processes have not been developed, or the quantity of the product produced does not justify the cost of continuous processing. Today, however, the instrumentation is less simple: it is not uncommon to see supervisory systems such as cascade control for two temperatures, for temperatures and flow, or for temperature and pressure used on batch processes to produce a better product at a lower cost.

A continuous process has been described as a group of batch processes interconnected with a minimum of storage space interposed between the various stages. In the evolution of continuous processing, it became necessary to locate the instruments for the various stages in one place, in order to provide adequate and economical supervision. The instrument panel board for a small unit was often installed in the pump house. As the size of the units increased, the panel boards grew to occupy the entire floor of a second story added to the pump house. The subsequent increase in size of units along with changes in the location of auxiliaries, such as the placing of pumps on or under the unit, and the need for more instruments resulted in housing of the panels in a building designed especially for them.

The Immediate Problem

With the increase in size of units and in complexity of operation, numerous problems arose such as closer supervision, better process control, and reduction of the sizes and costs of control houses. In some installations, the process engineers found that transmission lag from the point of measurement to the instrument and back to the valve was causing unsatisfactory control. Some panel boards became so long that the time required for a board man to make his rounds introduced undesirable intervals between observations of operation. For some processes the required instrument houses cost so much and occupied so much valuable space that it became necessary to make careful estimates of the value of locating the instruments all in one place.

The efforts of the past in the development of instruments have been largely along the lines of eliminating the human factor in process control. This is not always a desirable thing to do because upsets are generally caused not by instruments but by failure of system components, and human intelligence must be available to prevent or counteract upsets when the need arises. Even automatic controllers cannot correct for some failures. Long panel boards and the resulting time lag between observations of a great many instruments may result in serious upsets before corrective measures can be taken by the operator. The use of several operators to decrease the time lag and eliminate this difficulty has not always been successful because of unequal operator levels of experience or division of authority.

Current economic considerations are pushing many processing units to higher and higher throughputs, at the same time pushing the design of the process to have smaller and smaller capacitances. The failure of a pump, for example, for a matter of only minutes may not only spoil an appreciable quantity of product, but may cause damage resulting in extensive shutdowns. At such a time there is need for finger tip control available to an operator who has immediately before him an overall picture of operation of the unit.

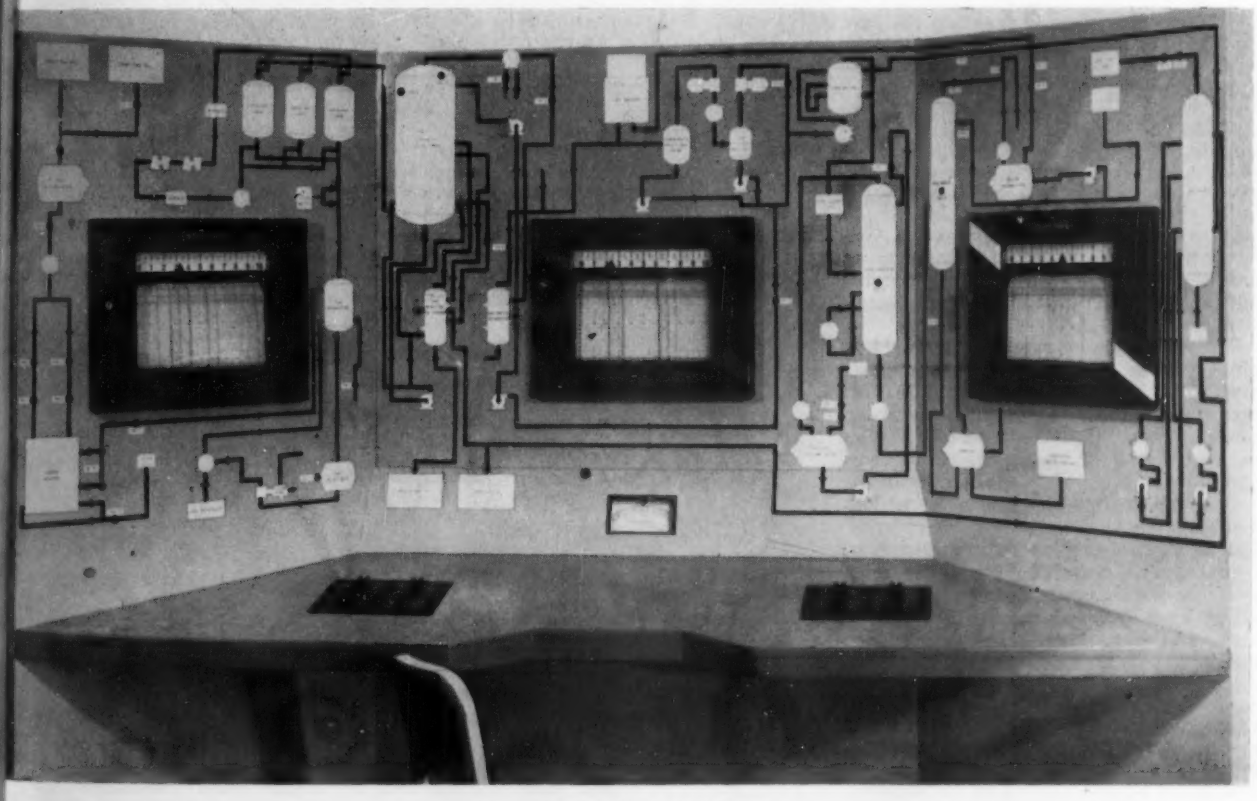

Fig. 1. The Panel Board of Tomorrow.

*Presented at the Third Annual Conference of the Instrument Society of America, Sept 13-17, 1948, Philadelphia, Pa.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

**Chief Application Engineer and Senior Development Engineer, respectively, of Brown Instrument Company, a Division of Minneapolis-Honeywell Regulator Company, Philadelphia 44, Pennsylvania.

With the increasingly rigid specifications of the end products and increasing complexity of the process necessary to meet all requirements, a higher level of operator intelligence is necessary to provide fast and unified human control with the present control panel equipment. Several companies have stated that they must employ operators of the level of technical school graduates in order to obtain the desired results. They have further pointed out that in order to hold operators of this educational level there must be a change in the method of controlling the process. It will be necessary to devise methods whereby possible fatigue due to present methods of operation is eliminated, the entire process is under finger tip control from one location, and the control supervision permits more skillful provision of an uninterrupted manufacturing process.

In many installations, the transmission lag inherent in locating a pneumatic controller hundreds of feet away from the primary measuring element, as well as from the control valve, is a factor which may cause unsatisfactory control. The magnitude of the effect of transmission lag is questioned by some engineers but the existence and possible importance of it have been brought to the authors' attention repeatedly. In many installations the lag cannot be eliminated because of the size of the unit, the unavailability of a control house location which would reduce the transmission time, or other reasons. Electric controllers would eliminate the lag, but they are not applied generally to the processes which encounter the problems described above because of hazardous atmospheres, although electrical measurement is becoming increasingly common and increasingly safe.

The "Panel Board of Tomorrow"

These points were brought to the attention of the authors in discussions with several process engineers. As a thorough investigation seemed desirable, it was decided to approach the problem of building a model which would offer better and easier centralized control, and then discussing it with engineers from a wide cross-section of industries. This model, shown by Fig. 1 and called "The Panel Board of Tomorrow" for want of a better name, has been discussed with approximately 100 engineers from a broad cross-section of industry.

The flow diagram represents the principal piping for a fixed bed catalyst unit. The multiple point strip chart recorder on the left records pressures, the center records thermocouple temperatures and the one on the right, flow and liquid level. The small black dots are lamps indicating places at which measurements are made. Each lamp lights as the corresponding record is printed. To the right is a bank of switches which permits the operator to select any recorded place of measurement and connects its measuring element so that he gets intermittent or continuous indication on the indicator in the lower center of the middle panel. As a possible future development, the bank at the left would provide means for going on manual control and means for remote setting of the control index.

The presentation of this console type panel naturally drew forth many and varied expressions of opinion. Four deserve notice here because they were heard so many times:

1. All instrument engineers agreed that the provision of means for a remote setting of control index is essential on any supervisory control panel.
2. It would be desirable, in many applications, to have one recorder show all the variables connected with a certain section of the process, i.e., temperature, pressure, flow, and liquid level on the same recorder.
3. A form of indication such as signal lamps should be provided for information concerning valve positions, pump operation, or condition of other control devices.
4. Means for remote pump control, including the proper valve manipulation, should be developed.

The authors, following these discussions, recognized the need for a "Remoteset" unit to provide remote setting of a control index; that is, the operator sitting at the console must be able to change the set point of any controller from the console. Such a unit will be described later in the paper. In any further discussion, it will be assumed that a Remoteset is an inherent part of the panel.

Although the desirability of recording all variables from the same section of the process on one chart is generally recognized, the feasibility of making a reasonably priced recorder for such service is still uncertain. A recorder for pneumatically transmitted variables can easily be used for any variable. The technical difficulty of recording thermocouple temperatures on the same recorder, operating directly from the thermoelectric potential, will result in extra cost. On many units this cost will not be justified in the opinion of many engineers.

The authors agree that there is a need for indication of pump operation. Often upsets are due to pump difficulties and future developments of the panel should provide control of such devices in order that pumps and valves may be operated from the control room in the proper sequence when an emergency occurs. The authors feel that equipment already developed for use in railroad signal towers or electrical generating stations can be adapted to provide the signalling and control required for such elements.

Components for Supervisory Panel

The next step, a time-consuming one, was the development of the components necessary for the panel board just described. The schematic wiring and piping diagrams for these components is shown by Fig. 2. There are essentially three components, the strip chart recorder, the Remoteset mechanism and a pneumatic controller transmitter installed on the unit. These devices meet all the necessary requirements; namely a method for manually changing the set point of a controller located at a distance, and a means in the controller for transmitting measurements back to the board where it would be both indicated and recorded.

It was the consensus of opinion that the panel board's flashing lights, which showed the places where measurements were being taken, served no useful purpose and possibly might be annoying to operators. A suggestion was made that they be replaced by small gauges that would continuously indicate to the operator the measured values and control point of each instrument.

It was decided to combine the means for setting the index of the controller with these small gauges, for several very desirable reasons. Such a combination would remove the Remoteset from the console, and leave space for the installation of thermocouple switch banks and for log books. Of primary importance was the fact that the set point indication would be on the same scale as that on which the measurement are shown. With such an arrangement when the control and set point of the locally mounted instrument coincide it will be indicated by the alignment of the target and pointer of the Remoteset as shown by Fig. 3. Of some importance in simplifying operation is the fact that with the Remoteset located on the flow diagram, the operator makes a change at the point where the change physically occurs in the process.

The pneumatic system of the Remoteset, shown by Fig. 4, operates on the null balance principle. The set point indicator as shown in Fig. 3, is moved by turning the set point adjusting knob located at the lower right-hand corner. If this adjusting knob is turned clockwise, thus moving the set point indicator upscale, force is applied to the

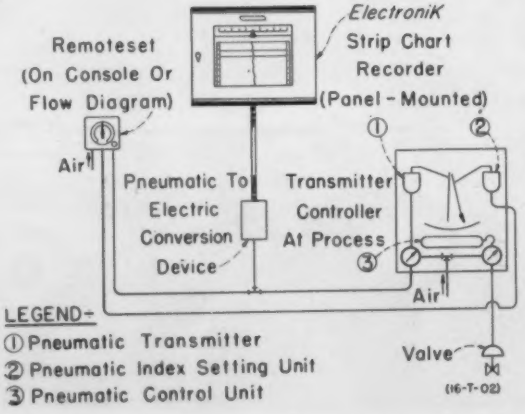

Fig. 2. Schematic wiring and piping diagram for Remoteset applications.

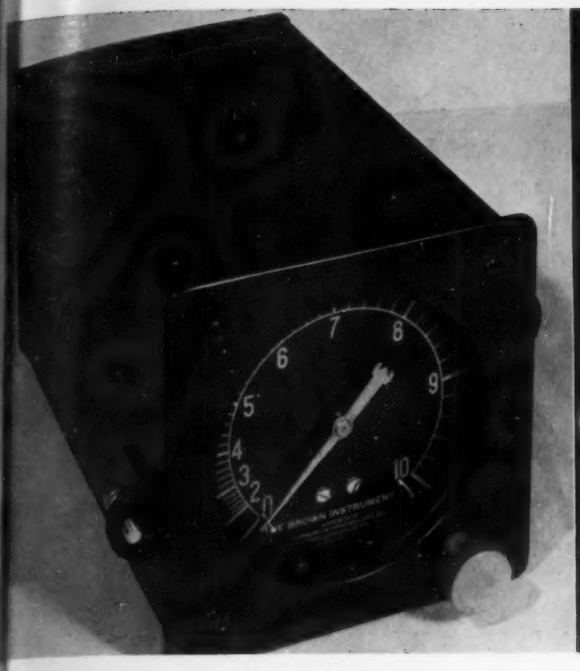

Fig. 3. Front view of Remoteset.

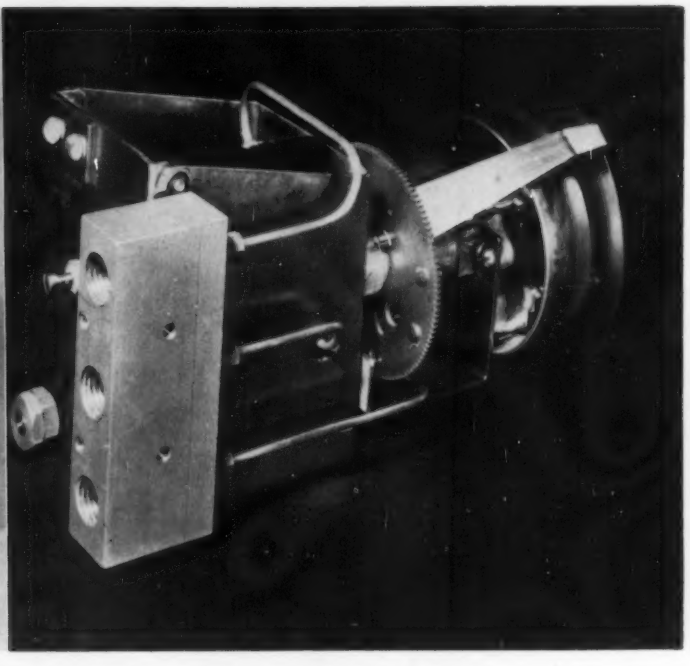

Fig. 4. Side view of Remoteset.

top of a bellows. The movement of the bellows causes the supply valve to open and increases the air output pressure. Since the output air pressure is applied to the interior of the bellows, in opposition to the applied force, the valve will again close when the two forces are equal. While this is occurring the transmitted output pressure is being applied to the setting mechanism in the controller which moves the index to a new position.

Records are needed if the operator is to observe the control trend, and they may also be needed for accounting. Where accounting records are required, the transmitter controllers can be of the recording type, although records at the supervisory panel will sometimes be adequate. There are two avenues open for presenting a record of the operation of a unit to operators using conventional industrial instruments. Each has ardent supporters.

The first is the use of multiple-pen instruments, with circular charts, favored by those whose applications require continuous, uninterrupted records of of the process variables because of rapid changes. Where critical pressures and flows are involved the need for uninterrupted recording may be the determining factor in selecting pen type instruments. Fig. 5 shows an arrangement for obtaining such records for three controlled variables using pneumatic transmission. A Remoteset unit, such as shown in Fig. 3, is necessary for each controlled variable.

The second avenue, for those applications where space conservation considerations outweigh the desire for an uninterrupted record, calls for multiple point strip chart recorders, such as are illustrated in Fig. 6. Each can provide records of up to 16 process variables. Under optimum conditions, the interval between printing two consecutive records of the same variable can be numerically equal in seconds to the number of records. As for the pen-dragging instrument of Fig. 5, one Remoteset device is necessary for each controlled variable.

There are functional limitations on the use of the cyclic printing inherent in the strip chart instruments. These limitations must be weighed against the reduced panel area which is required. The optimum printing speed is attainable only if consecutive records are not widely spaced on the chart. If the magnitude of many process variables changes frequently, the optimum recording time cannot be obtained. However, a satisfactory recording time can often be attained by recording only six or eight variables on one instrument. The use of fewer records is endorsed by the expressed opinion that the inclusion of sixteen records on one chart will be entirely too confusing to the operator.

Several suggestions have been adadvanced for taking advantage of the length of the scale on these multiple point recorders to spread the records over different sections of the chart in order to eliminate the possible confusion of crossing records. At the present time, demands for flexibility in chang-

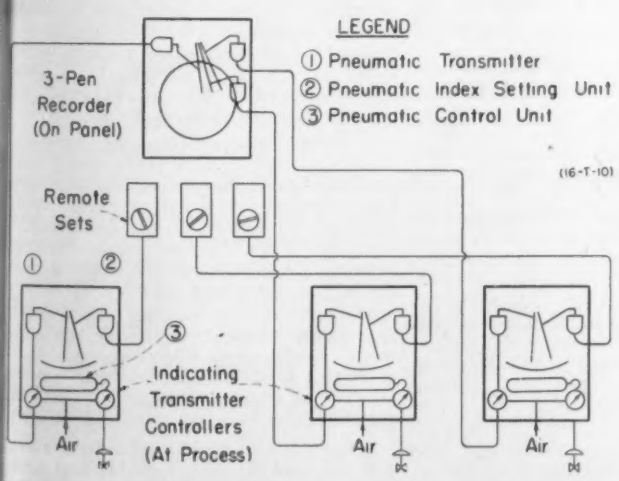

Fig. 5. Schematic piping diagram for Remoteset applications using Multiple Pen-dragging Recorder.

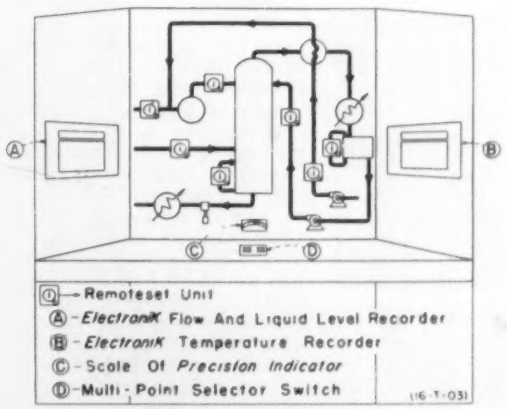

Fig. 6. Typical Remoteset panel.

ing the magnitudes of process variables have caused the span of the multiple point recorders to correspond with the span of the primary measuring instrument.

The multiple point recorder is an electrical instrument. Therefore, where pneumatic transmission is used, some means of conversion to an electric signal is required, as shown in Feg. 2. Units for making the conversion have been developed in three general types, most of these actuated by a spring and bellows unit, which has the conventional transmitter pressure span, and receives the pneumatic signal. The pressure change is converted to an electrical change by one of three methods:

1. The first, a direct adaptation from many flow meter applications, uses an inductance bridge circuit. The armature moving in the coils of the convertor until is coupled to the pneumatic bellows. In order to obtain good linearity, the multiple point recorder must contain a similar inductance coil and armature.
2. The second uses a linear differential transformer for producing a calibrated a-c. voltage in response to armature motion. This can be used with an a-c. potentiometer type of instrument having either a conventional slidewire or a second transformer.
3. The third conversion unit is a d-c potentiometer which can be energized from the same source as the measuring circuit of the recorder.

All of these methods are expected to require little additional maintenance. The d-c. potentiometer method is offered because it permits high speed recording of a mixture of thermocouple voltages and signals received from pneumatic transmitters located on the processing unit.

Future Developments

Future developments of supervisory control panels, such as have been described, must be determined by the operating results. Various designs have been sketched, several are in the process of construction, and a few are in everyday use. Only by a process of trial and error, and by the accumulation of operator experience, can some of the schemes be proved.

One development appears to be in the near future. That is the inclusion of means for switching to manual control, and for controlling certain parts of the unit manually from the supervisory control board. Developments are completed on Remoteset devices that provide for individual setting of indices and then switching to provide cascade control.

Another development which has been discussed by many engineers is the need for dial switching for indicating a large number of variables on one indicator. Where the number of variables, usually thermocouple thermocouples, is very large, dial switching is desirable as a means for panel area reduction.

A need may develop for an "upset panel" to which the operator can switch certain critical variables during start-up or during upsets. Those variables will be recorded continuously, and probably at a fast chart speed.

Cost

Of primary importance is a cost comparison of the new with conventional methods. Because of the many factors involved, this can be given only in broad terms, without actual cost differences. An attempt was made by the authors to determine an average cost based on some factor such as unit area or volume. Cost figures were obtained from both contractors and those who built their own control houses. When these were analyzed, it was impossible to determine an average figure because of the wide variation in cost computation.

The cost of Remoteset equipment depends on such factors as the use of multiple pen circular chart or multiple point strip chart recorders, the need for explosion-proofing converters, and the elaborateness of the flow diagram which is placed on the panel board. The difference in cost of equipment supplied by various manufacturers is also a factor in making a cost comparison. Generally, the Remoteset instrumentation as shown by Fig. 2 or Fig. 5 is more costly than the conventional type; but the authors' analysis shows that for many applications the higher cost of instrumentation is offset by the reduction in control house costs. Cost must be investigated for each individual installation.

Conclusion

The console type panel provides a continuous indication within a small area, and operators can immediately observe upsets since a change in the position of a pointer will change the general pattern on the board. Where upsets do occur they can be followed and the trend observed on the strip chart recorders. Corrective action by the operator is initiated on the flow diagram at the point where the action actually occurs in the process. If it is desirable, a separate circular chart instrument, possibly with a faster-than-normal speed of rotation, could be cut in for trend observations. Use of compact and inclusive panels will not only reduce physical fatigue and make instrumental supervision more attractive to operators of a high intelligence level, but it can be expected to result in smoother control and more intelligent prevention of process interruption.

Further work is justified by the apparent possibilities in systems of this type. Extensive development by several manufacturers is now under way. Ultimate proof of the possibilities can only be obtained by further installations in as many industries as possible. The results of such work will be closely studied.

Who's Who in the I.S.A.

DR. ARNOLD O. BECKMAN,
(ISA National Vice-President, President California Section)

I was born in Cullom, Illinois, and attended high school at the University High School, Normal, Illinois. After graduation, I served in the Marine Corps until the close of World War I when I entered the University of Illinois.

I received a degree of B.S. in Chemical Engineering in 1922 and M. S., in Physical Chemistry in 1923. The following year I spent at the California Institute of Technology doing graduate work. Then I went back to New York where I spent two years with the Bell Telephone Laboratories working with Dr. Walter A. Shewhart in his pioneering work on statistical methods of quality control. I returned to the California Institute of Technology in the Fall of 1926 and continued graduate work, receiving a Ph.D., degree in Photo Chemistry in 1928. I stayed on the chemistry staff until 1940.

During this period I was actively engaged in consulting practice. One outgrowth of which was the formation in 1934 of National Technical Laboratories, which has been concerned with the development and manufacture of instruments primarily for chemical laboratories and chemical process control. Chief Instruments have been glass electrode pH equipment and spectrophotometers. Recently Geiger counters and other instruments for radioactivity measurements have been included. Since 1939 I have been president of this corporation. In the interest of obtaining a better battery control rheostat, a multiturn rheostat potentiometer (called Helipot was developed for use in the National Technical Laboratories' instruments. During the war this device became a critical component of certain radar equipment. A separate corporation, The Helipot Corporation, was formed in 1944 to manufacture the units and to develop additional potentiometric devices. I have been president of this company since its founding. I am president also of another corporation, Arnold O. Beckman, Inc., which manufactures oxygen analyzers and gamma ray dosimeters.

I have been active in American Chemical Society affairs for many years and have been interested in the Instrument Society of America since its inception. Currently, I am president of the California Section in addition to being Vice President of the National Society. I am also a member of several other professional groups including the American Association for the Advancement of Science, Electrochemical Society, as well as technical and professional fraternities including Sigma Xi, Phi Lambda Epsilon, Alpha Chi Sigma.

I have a wife and two children, Patty age 15, and Arnold, age 11, and enjoy living in Altadena, California, where we established our home 15 years ago.

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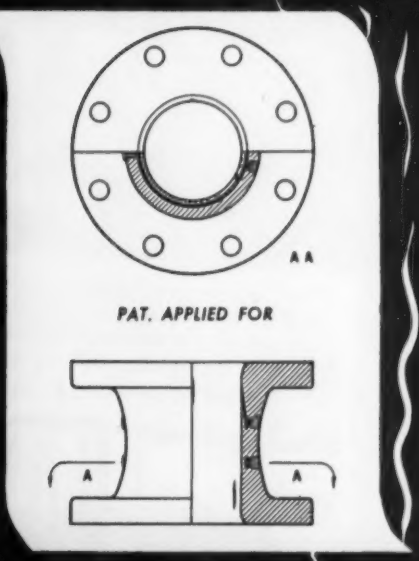

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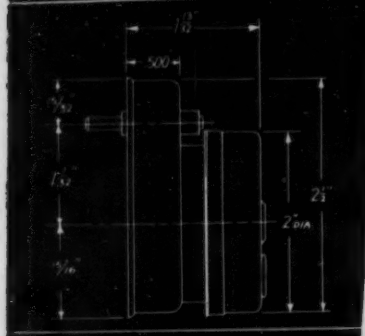

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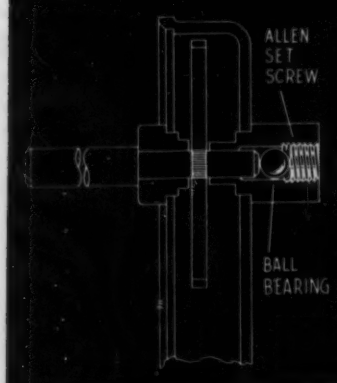
OSCILLATING SHAFT

Normal rotary movement of drive shaft is converted to oscillating motion by special linkage between drive wheel and shaft. Standard model #1891, using 30 rpm motor, furnishes complete 30° shaft oscillation every 2 seconds. Control of current pulses in electric fence timers is typical application.



SPECIAL THRUST BEARING

Drive shaft and bearing assembly designed to absorb vertical thrust. Special shaft assembly incorporates ball bearing; set-screw assures proper adjustment of shaft and bearing. Typical applications include displays, turntables, barber poles . . . all installations where load on output shaft is heavier than can be safely carried by standard construction.

These designs are typical of the versatility and wide range of the Haydon line . . . providing timing mechanisms to meet special requirements. If your needs are unusual, consult Haydon timing engineers. Send for new Haydon Engineering Data Catalog.

Write HAYDON, 2011 Elm Street, Torrington, Connecticut

HAYDON

MANUFACTURING COMPANY, INC.
TORRINGTON, CONNECTICUT
HARNESS TIME TO YOUR PRODUCTS
SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION

SECTION NEWS

(*Continued from Page 1052*)

Mr. Pierson gave a description of "Hi Operations", and the things that will go o in the plant when they get into operation showing what part a half million dollars worth of instrumentation will play. Our nex meeting will be favored by a discussion o uses of the photo-electric cell and the stro boscope, by Mr. Sylvester A. Cathey of th Naval Air Station. —L. NEEDHAM, Corr.

TULSA

"Automatic Control of Fractionating Col umns" was the subject scheduled for the Oct. 11 meeting. The speaker was Mr. Vin cent V. Tivy of The Foxboro Co.

WAYNE COUNTY

The regular meeting was held Oct. 18, in St. Stephens Episcopal Church Hall. There was an excellent dinner and much informal shop talk. The door prize, a pocket tire gage, was won by George Huff. A short business meeting followed. George Huff, our convention delegate, brought us up-to-date on convention business and plans. The program consisted of talks by members on various divisions of purometry. We got a lot of good from an exchange of ideas and experiences and we plan to have more meetings of this sort. Next meeting will be held at the same place, Nov. 15, and the program will be a talk on Conoflow Valves by Herb Barnum. —JOHN MACPHERSON, Corr.

I.S.A. EMPLOYMENT SERVICE

Forward your letter to INSTRUMENT SOCIETY OF AMERICA, 1117 Wolfendale St., Pittsburgh 12, Pa.

SALES ENGINEERING COMPANIES. Manufacturer of highly specialized high pressure research apparatus—autoclaves, fittings, tubing, etc., wants Sales Engineering firms to represent them in various cities throughout U. S. A. including St. Louis, Los Angeles, Houston, Cleveland, Tulsa, Boston, etc. Excellent opportunity in new field of research. Write giving list of other products sold and other pertinent data. Box 198.

INSTRUMENT ENGINEER, mechanical engineering graduate, knowledge of flow measurement theory using mercury manometers and bellows differential type meters, practical experience in flowmetering applications, experience in carrying out development programs, knowledge of factory methods and small parts manufacturing. Box 199.

INSTRUMENT ENGINEER. Unusual opening for an instrument and control engineer. Experience in the viscose industry desirable. Location, New York. Box 200.

INDUSTRIAL INSTRUMENT SALESMAN. Eastern manufacturer requires experienced salesman for New York, New England and Pittsburgh areas. The line consists of industrial dial and recording thermometers and temperature controllers. State previous experience, age and salary desired. Box 201.

INSTRUMENT TECHNICIAN. Atomic power work. Should have some experience in electrical, electronic and mechanical equipment. Located upstate New York. Box 202.

STEEL MILL SALES ENGINEER. Mechanical Engineering graduate with five years experience in steel mill instrumentation or with combustion control used in steel mill operation. Applicant should have good sales personality. The need for this man is immediate and urgent. Location Chicago. Box 203.

INSTRUMENT SERVICE ENGINEER. Mechanical engineering graduate for intensive training in steel mill instrumentation. Any experience with steam power, process or steel mill instruments will be an advantage. An excellent opportunity leading to Engineering Sales. Location Chicago. Box 204.

TEST ENGINEER for Philadelphia Instrument Manufacturer. Work consists of inspection of materials and inspection and testing of completed devices, mechanically, hydraulically and electrically. Man with experience in the maintenance of flowmeter equipment or college graduate in M.E., C.E., or E.E. Box 205.

INSTRUMENT ENGINEERS (two) for application work involving design, installation and operation of chemical plant process instrumentation. B.S. degree in engineering required. Location Texas. Box 206.